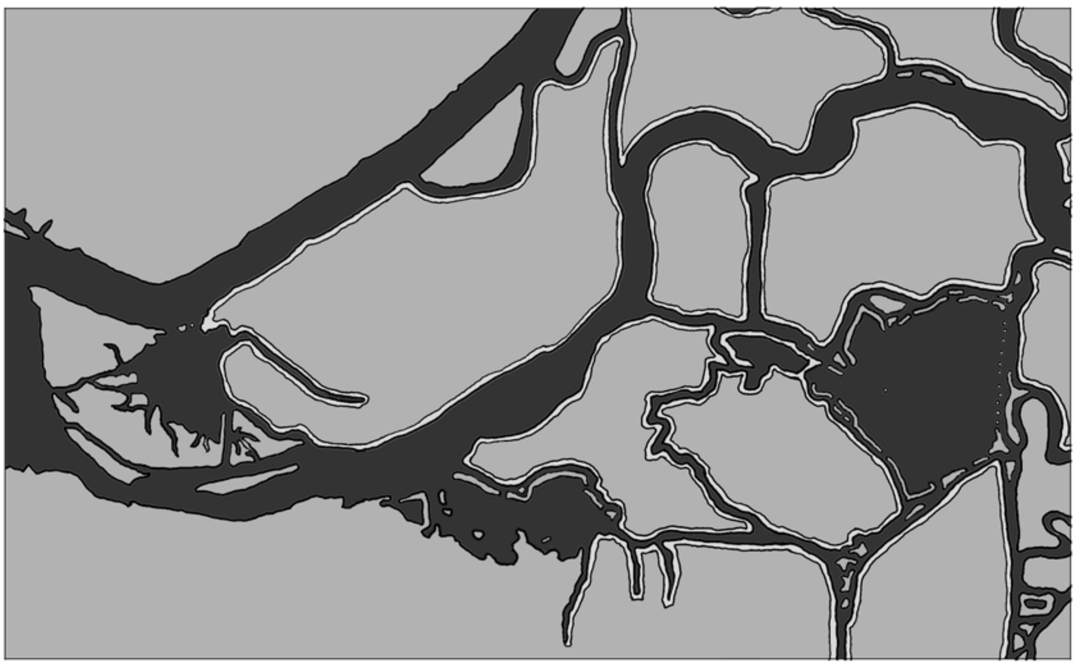
FLOODED ISLANDS

CONCEPTUAL ALTERNATIVES REPORT



Natural Heritage Institute
May 1, 2005

Prepared for:
California Department of Water Resources
Bay-Delta Office
901 P St, 3rd Floor
Sacramento, CA 94236

Contact:
Dan Fua
North Delta Programs
Bay-Delta Office
California Department of Water Resources
901 P Street
Sacramento, CA 95814
e-mail: dfua@water.ca.gov
Telephone: (916)651-9823
FAX: (916)651-9678

For Submittal to:
CALFED Bay-Delta Authority
650 Capitol Mall, 5th Floor
Sacramento, CA 95814

Prepared by:
Natural Heritage Institute
100 Pine St, #1550
San Francisco, CA 94111

Contact:
John Cain
(415)693-3000 x108

Table of Contents

1. Introduction

1.1. Description and Goals of Flooded Island Feasibility Study

The Flooded Islands Feasibility Study is a project of the Department of Water Resources (DWR) to evaluate the feasibility, benefits, and potential impacts of reconfiguring three flooded Islands in the Delta: Franks Tract, Big Break, and Sherman Lake:

The objectives of the project are to improve:

- Ecosystem values: Fish and Wildlife Habitat
- Recreational Opportunities
- Water Quality: reduce salinity in the central and southern Delta.

1.2. Purpose and Organization of the Conceptual Alternatives Report

The purpose of the Conceptual Alternatives Report is to identify and screen a broad range of opportunities for modifying flooded islands and adjacent lands and waters to improve ecosystem values, drinking water quality, and recreational amenities. The report separately identifies and evaluates options for achieving each of these objectives in the following 3 chapters. The different options are organized as separate elements, each of which can be implemented independently or in combination with other water quality, ecosystem, or recreation elements. Ultimately, the most promising elements will be combined to form a suite of alternatives which will be further evaluated in subsequent feasibility and modeling analyses. This further analysis is documented in the Flooded Islands Final Feasibility Report (feasibility report).

1.3. Next Steps: Combine Elements into a set of Alternatives for Evaluation

At this stage in the drafting process, we have not attempted to package these elements into different alternatives. Nor have we considered the interaction between the separate water quality, restoration, and recreation improvement elements. Packaging the most promising elements into a limited suite of alternatives is the essential next step. This is documented in the feasibility report.

2. Water Quality Elements

The intent of the water quality elements exercise described below is to document our initial assumptions about how various physical changes to the delta will impact both water quality and other desired conditions and outcomes. These assumptions will be revised, reconsidered, and modified by expert feedback, model results, and continued research.

Water quality alternatives that pass this level of screening, will be advanced onto the project modelers for further detailed consideration and modeling and documented in the feasibility report.

The inherent complexity of tidal systems in general and the Delta in particular requires a multidimensional, comprehensive analysis of any proposed changes. One of the first steps in any Delta design project is to identify, define, and articulate the many relationships both between the proposed changes and the desired results AND between the proposed changes and unintended consequences. This section is an initial attempt to capture the complexity of the Delta and the many consequences of any modifications the project may propose on behalf of improving water quality. This section will define the various parameters and describe the direct and cascading linkages between them.

Many of the descriptions of elements and scenarios in this section are taken verbatim (or nearly so) from *Franks Tract Scenarios – Working Notes (9/15/04)* by John Burau.

2.1. Summary of water quality improvement elements

The analysis considered four water quality improvement elements in various combinations and configurations: levee repairs; permanent barriers; operable tide gates; and large-scale marsh restoration.

Levee repairs include both repairing a few key levee breaches and large scale levee reconstruction. Repaired levees generally reduce the hydraulic connection between salty water entering from the west and the fresh water corridor in the eastern Delta. Permanent barriers are similar to levees but they run perpendicularly across channels, rather than along them. They eliminate hydraulic connectivity between adjacent reaches of a channel or bodies of water.

Operable tide gates would remain open throughout most of the year and would only be operated for salinity control in the fall/early winter period. In theory all of the gates (no matter the location) would be operated in one of two ways: (1) based on tidal current phase - closed on flood tides, opened on ebbs, or, (2) closed when the specific conductance reaches a threshold value on flood tides and then subsequently opened when the water level difference across the gates indicates an ebb tide condition. The tide gates would be designed so that small boats could pass when they are open, as is the case with the Delta Cross Channel.

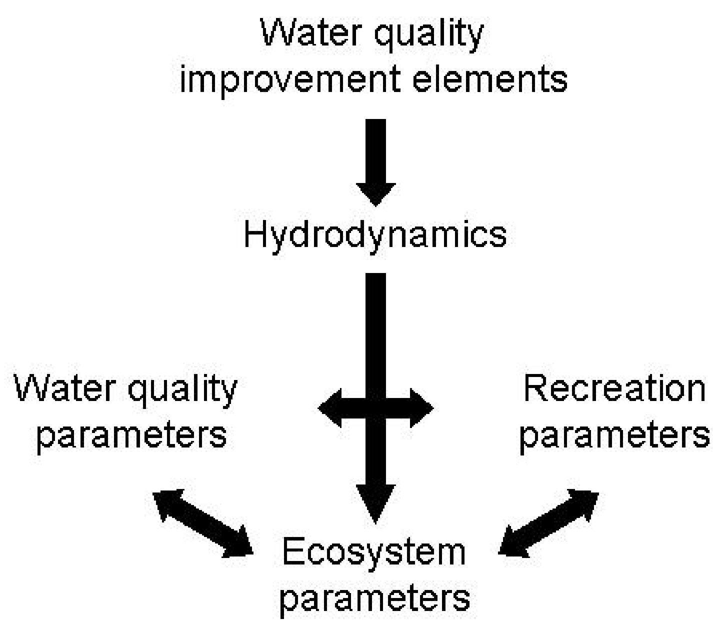
Large-scale marsh restoration on flooded islands removes the hydraulic connection between the flooded island and the Delta. The idea would be to repair the ring levees and fill in the islands to approximately MLLW or higher to create a marsh environment where recreational activities such as fishing/boating would be replaced by wildlife viewing, canoeing/kayaking, duck hunting, etc.

2.2. Evaluation Approach

We developed a pre-modeling screening tool to evaluate various water quality improvement elements and their potential impact on water quality, ecosystem, and recreational parameters.

The water quality improvement elements impose a physical change to the Delta. These in turn impact hydrodynamics in the Delta, which in turn impacts water quality, ecosystem, and recreational parameters. Additionally, changes to many of these parameters impact other parameters of concern (Figure 2.1).

Figure 2.1 Cascade of impacts



Project partners identified eight key hydrodynamic parameters that would be impacted by the sort of water quality elements described above. These eight hydrodynamic parameters would impact fourteen key parameters of concern. Key parameters are those that are either a) directly related to the project goals and objectives, b) of interest to key stakeholder groups, or c) have some cascading effect on other parameters of interest. Below we describe the key parameters and their rationale for inclusion in the analysis.

Hydrodynamic Parameters

- *Connectivity*: Connectivity is inverse to the distance a particle or organism must travel to get from point A to point B as determined by the network of channels, sloughs, and levees.

- *Velocity gradients*: The rate at which the current flows at key locations.

- *Tidal trapping*: Water (and/or particles) temporarily trapped by tidal flows within a shoreline indentation.

- *Tidal pumping*: Mixing of salinity resulting from irregular bathymetry.

- *Residence time*: The length of time for a particle entering a water body to be removed by natural forces such as tides and currents.

- *Length of tidal excursion*: The maximum distance along the estuary or tidal river that a particle moves during one tidal cycle of ebb and flow.

- *Tidal prism (in Franks Tract):* Total amount of water flowing into an estuary or out again with movement of the tide (excluding any freshwater flow). Tidal prism = height of tide x area flooded.

- *Tidal stage*: The elevation of the water surface in a tidally controlled water body.

Water Quality Parameters

- *Salinity (at flooded island)*: The concentration of salts, usually sodium chloride, in water at the flooded island of interest. The salinity in the flooded island is of interest because it can have a cascading effect on salinity at the pumps, native and sport fisheries, and submerged aquatic vegetation.

- *Salinity (at pumps):* The concentration of salts, usually sodium chloride, in water at the export pumps in the south Delta. Reducing salinity at the pumps is one of the main goals of the Flooded Islands project.

- *Temperature*: Water temperature in and around Franks Tract. Water temperature is of interest because it can have a cascading effect on dissolved oxygen, mercury methylation, primary productivity, native and sport fisheries, and submerged aquatic vegetation.

- *Dissolved Oxygen*: Oxygen that is dissolved in water and therefore available for use by plants (phytoplankton), shellfish, fish, and other animals. Dissolved oxygen is of interest because it can have a cascading effect on mercury methylation, primary productivity, native and sport fisheries, submerged aquatic and vegetation.

- *Dissolved Organic Carbons (at pumps):* The concentration of organic carbons at the export pumps in the south Delta. Dissolved Organic Carbons are of interest because they are desirable in the western Delta for ecological productivity but are are precursors to the formation of harmful disinfection byproducts in municipal water supplies and are undesirable at the pumps. Source water with high DOC concentrations requires additional treatment steps, increases the cost of treatment, and may lead to increased health risk from exposure to disinfection byproducts.

- *Mercury methylation*: The process that transforms mercury into its more bio-available form. Mercury methylation is of interest because it makes mercury already in the Delta system (either from riverine or atmospheric sources) bio-available for uptake and concentration in species of interest.

Ecosystem Parameters

- *Primary productivity*: The transformation of chemical or solar energy to biomass, mostly through photosynthesis. Increasing primary productivity in the Delta is of interest due to its beneficial effect on the Delta food web and species of interest.

- *Habitat variability*: The diversity of habitat types (both aquatic and terrestrial) available to desirable flora and fauna. Habitat variability is critical to the survival of species of interest in the Delta.

- *Native fishery*: Prickly goby, sculpin, tule perch, Delta smelt, salmon, and splittail. Improving the native fishery is a goal of the Flooded Island project.

- *Sport Fishery*: Black bass and striped bass. The sport fishery around Franks Tract is of great economic and recreational value.

- *Submerged Aquatic Vegetation*: Rooted, submerged macrophytes that grow entirely below water. SAVs in the Delta, particularly *Egeria densa* can have deleterious effects on habitat availability, recreation, and food web dynamics.

Recreational and Other Parameters

- *Boating Access*: Boating access refers to both the extent of navigable waters and the connectivity of navigable waters.

- *Island/Levee Stability*: Maintaining island and levee stability for the in-Delta population, for Delta agriculture, and to maintain fresh water channels, is a primary goal of the CALFED program.

- *Flood Protection*: Maintaining flood protection for the in-Delta population and for Delta agriculture is a goal of the Department of Water Resources.

Matrix Description

We analyzed the impact of changes to the eight hydrodynamic parameters on the fourteen water quality, ecosystem, and recreational parameters through a matrix exercise. The matrix, included later in this section, consisted of hydrodynamic parameters along the y-axis and water quality, ecosystem, and recreational parameters along the x-axis. The direction of change and relative magnitude of the impact (relative to other alternatives and parameters) is noted with a small, medium, or large arrow.

The cumulative impact of all eight hydrodynamic parameters is indicated in the right most column of the matrix. This column is reproduced in the summary matrix. In the summary matrix, green arrows indicate a change that is consistent with the goals of the project. Red arrows indicate a change that is contrary to the goals of the project. Gray indicates a change neither consistent nor inconsistent with the project goals.

2.3. Description of Alternatives

We describe the seventeen alternatives we considered in the section below. The statements on how those alternatives performed are just informed estimates and assumptions. We performed more detailed analysis on a selection of these alternatives as documented in the feasibility report. Alternative descriptions FT-02-FT-11 are taken almost verbatim from *Franks Tract Scenarios – Working Notes (9/15/04)* by John Burau.

2.3.1. Alternative FT-01

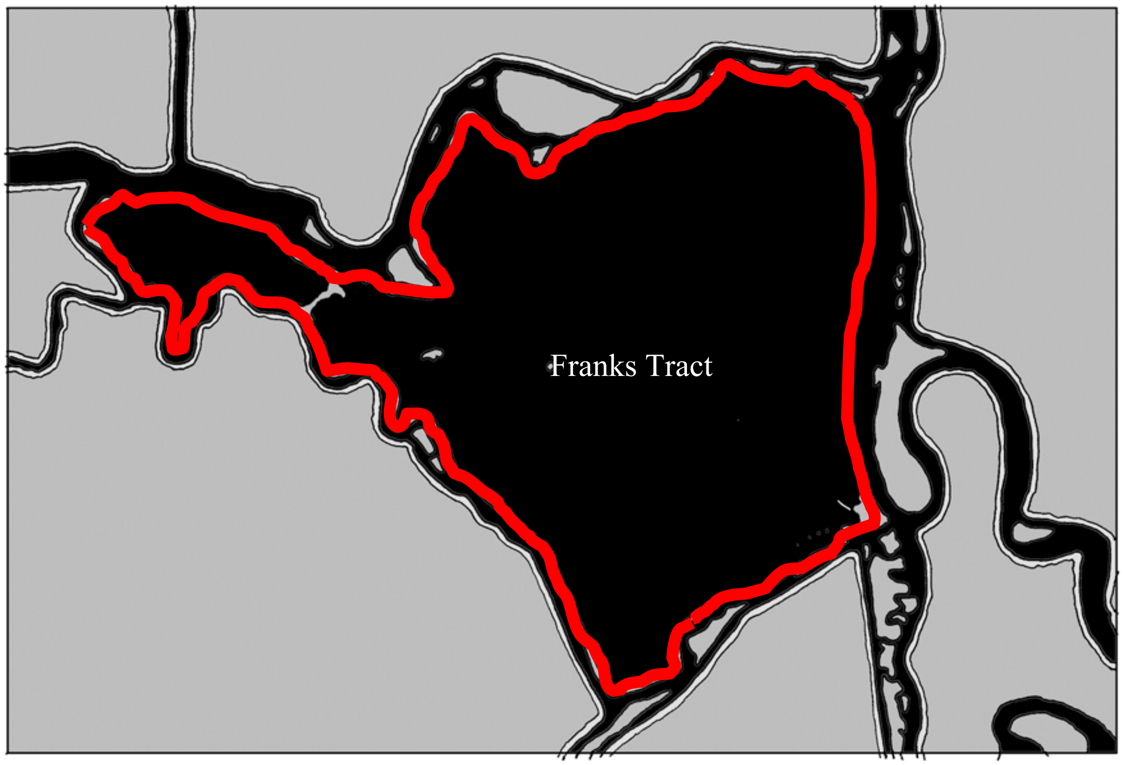


Figure 2.2 – Alternative FT-01

Description: Repair all levees surrounding Franks Tract (Figure 2.2). The interior of Franks Tract would remain as open water.

Table 2.1. Alternative FT-01 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
	Effect on:									
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
Water Quality	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	■
Water Quality	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
Water Quality	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
Water Quality	DOC (at pumps)	↓	■	↓	↓	■	↑	↓	?	↓
Water Quality	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
Ecosystem	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
Ecosystem	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
Ecosystem	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
Ecosystem	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
Recreation/Other	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
Recreation/Other	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■	Beneficial change
■	Neutral change
■	Unbeneficial change

Arrows indicate direction of change

Key points: This scenario essentially removes the hydraulic connection between Franks Tract and the Delta. Based on initial modeling presented by RMA at Flooded Island project partner meetings, disconnecting Franks Tract hydraulically probably results in a small decrease in salinity at the pumps, if any. The levees prevent tidal trapping and mixing in Franks Tract but they also increase tidal excursions deeper into the Delta. Franks Tract, in its current state, also serves as a fresh water reservoir in the spring. New levees would prevent this function.

Eliminating hydraulic connectivity has a negative effect on the native and sport fisheries and boating in the area. Additionally, having to build a complete ring levee around Franks Tract makes this alternative less feasible than others, less intensive alternatives.

2.3.2. Alternative FT-02

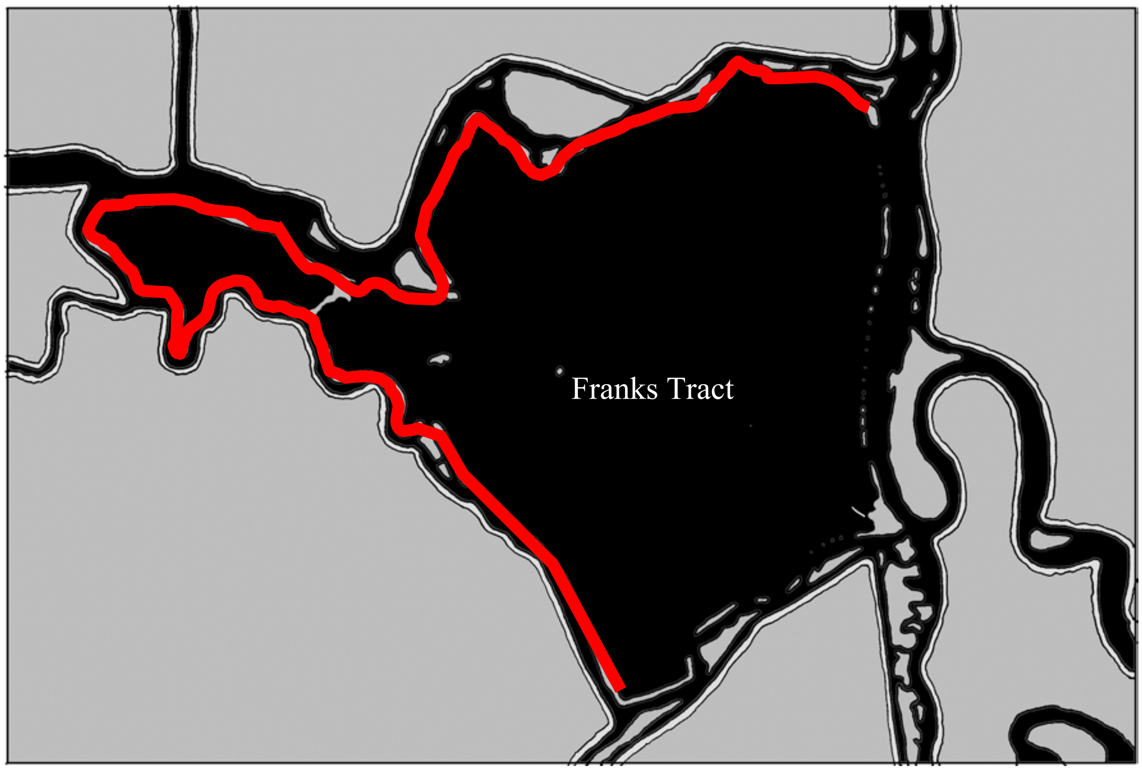


Figure 2.3 – Alternative FT-02

Description: Repair west and north levees (Figure 2.3).

Table 2.2. Alternative FT-02 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
	Effect on:									
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
	DOC (at pumps)	↑	↑	↓	↓	↑	↑	↓	?	
	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■ (green)	Beneficial change
■ (grey)	Neutral change
■ (red)	Unbeneficial change

Arrows indicate direction of change

Key points: (From Burau) This scenario is based on the observation that a water parcel released at the San Joaquin/False River junction at the beginning of flood tide doesn't quite reach Old River in a single tidal cycle. In more technical terms, the tidal excursion in False River is less than the length of False River. This scenario is, therefore, based on the premise that we only need to repair the levees within a tidal excursion of the San Joaquin River to significantly reduce transport of salt to the pumps. Although the tidal excursion in False River (and elsewhere!) could significantly increase as a result of the levee repairs. However, it may be possible to construct a narrow (control) section in False River that would limit the tidal excursion to the length of False River. We should note that historically, False River did not connect to Old River, this connection is man made.

The reduced connectivity is likely to reduce salinity at the pumps slightly. Leaving the back end of Franks Tract open could either serve to mute salinity intrusion deeper into the Delta, or it could still provide reduced tidal trapping and pumping. The increased residence time, particularly in western Franks Tract is of concern both for growth of unwanted SAV and potential mercury methlyation. This alternative also blocks key boating access points into and across Franks Tract.

2.3.3. Alternative FT-03

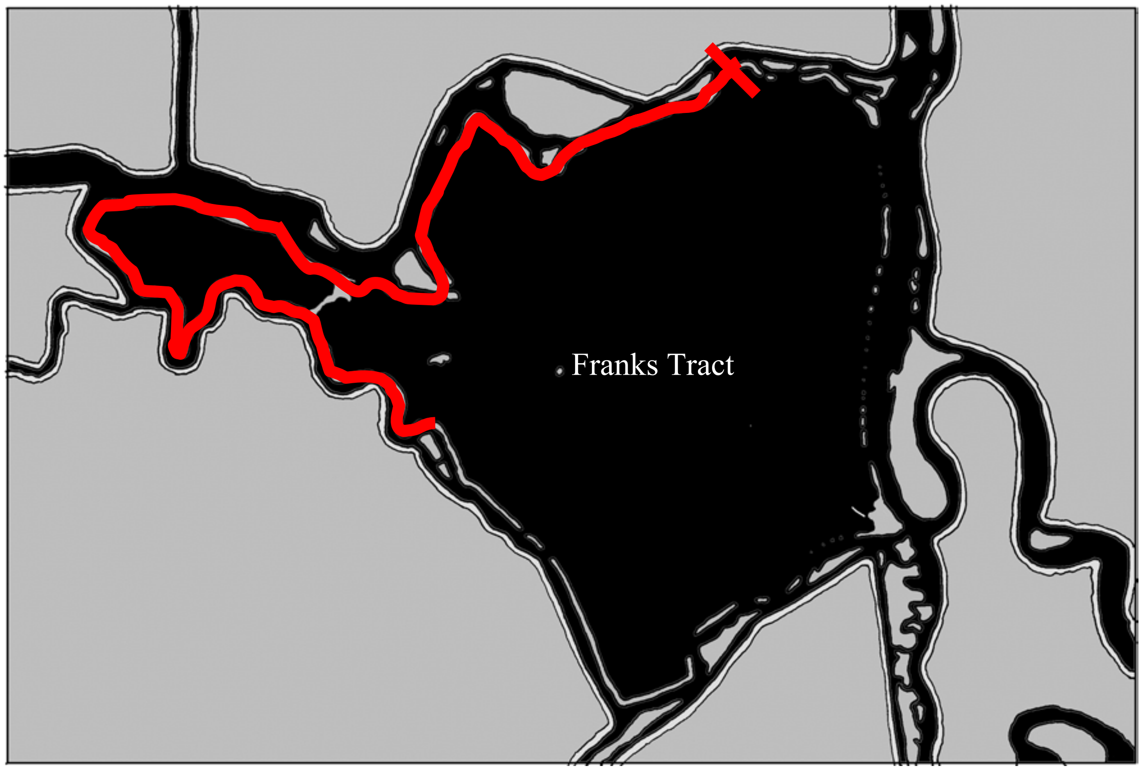


Figure 2.4 – Alternative FT-03

Description: Repair west and north levees and add a permanent barrier on E. False River (Figure 2.4).

Table 2.3. Alternative FT-03 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
	Effect on:									
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
Water Quality	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
Water Quality	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
Water Quality	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
Water Quality	DOC (at pumps)	?	↑	↓	↓	↑	↑	↓	?	■
Water Quality	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
Ecosystem	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
Ecosystem	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
Ecosystem	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
Ecosystem	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
Recreation/Other	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
Recreation/Other	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■	Beneficial change
■	Neutral change
■	Unbeneficial change

Arrows indicate direction of change

Key Points: (From Burau) This scenario is similar to Alternative FT-02 except that a barrier is installed on E. False River. This barrier insures that Bay-derived salt will not traverse False River and enter Old River and the fresh water corridor. The barrier was purposely placed in False River west of several large breaches to enhance north-south exchange within Franks Tract which could reduce the negative effects of increased residence times within Franks Tract. This barrier would increase the residence time in Franks Tract immediately east of the barrier and could increase the tidal flows and tidal excursion in Piper and Taylor Sloughs, with unknown consequences. This scenario would significantly reduce boat access on Franks Tracts east and north boundaries.

Similar to Alternative FT-02, the reduced connectivity is likely to reduce salinity at the pumps slightly. The increased residence time, particularly in western Franks Tract is of concern both for growth of unwanted SAV and potential mercury methlyation. This alternative also blocks key boating access points into and across Franks Tract.

2.3.4. Alternative FT-04

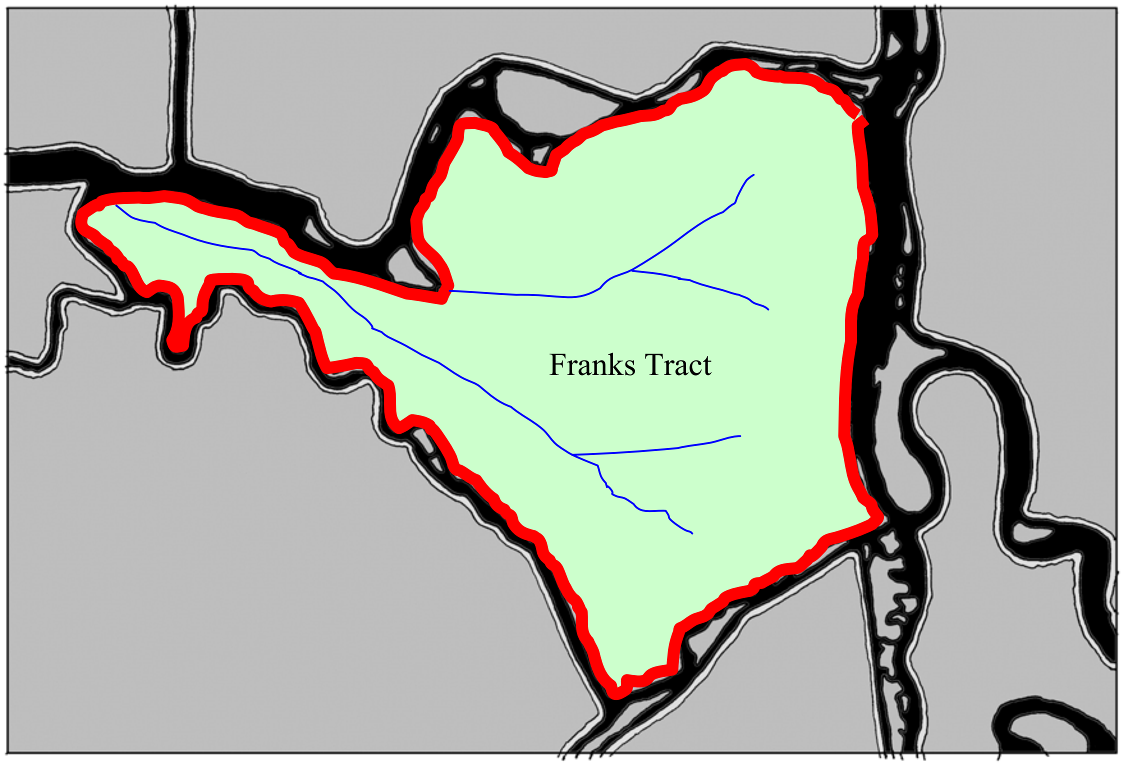


Figure 2.5 – Alternative FT-04

Description: Repair all levees surrounding Franks Tract (except for small breaches on Franks perimeter) (Figure 2.5).

Table 2.4. Alternative FT-04 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↑	↓	↓	↑	↑	↓	↑	
	Effect on:									
Water Quality	Salinity (at Franks Tract)	↓	↑	↓	↓	n/a	n/a	↓	?	↓
Water Quality	Salinity (at pumps)	↓	↑	↓	↓	n/a	↑	↓	↑	■
Water Quality	Temperature	↑	↓	↑	↑	↑	↓	↑	↓	↑
Water Quality	DO	↓	↑	↓	↓	↓	↑	↓	↑	↓
Water Quality	DOC (at pumps)	↑	↑	↓	↓	↑	↑	↓	?	↑
Water Quality	Mercury methylation	n/a	↓	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↓	↑	↑	↑	?	↑	↑	↑
Ecosystem	Habitat variability	↑	↑	↓	n/a	↓	↑	↓	↑	↑
Ecosystem	Native fishery	↑	↑	↓	↓	↑	↑	↓	↑	↑
Ecosystem	Sport Fishery (black bass, striped bass)	↑	↑	↓	↓	↑	↓	↓	↑	↑
Ecosystem	SAV	n/a	↓	n/a	n/a	↑	↓	↑	?	↓
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
Recreation/Other	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
Recreation/Other	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■	Beneficial change
■	Neutral change
■	Unbeneficial change

Arrows indicate direction of change

Key points: (From Burau) This scenario essentially removes the hydraulic connection between Franks Tract and the Delta. The idea would be to create a marsh environment where recreational activities such as fishing/boating would be replaced by wildlife viewing, canoeing/kayaking, duck hunting, etc.

Initial modeling runs by RMA indicate that restoring Franks Tract to MLLW is unlikely to result in a major improvement in salinity at the pumps for the same reasons as stated in FT-01. While this would likely result in enormous benefits for the native fishery and other ecological objectives, it would greatly impact the existing recreation. More importantly, the lack of fill material necessary for this undertaking makes it infeasible in the short term and certainly less feasible in general than other alternatives.

2.3.5. 2.3.5. Alternative FT-05

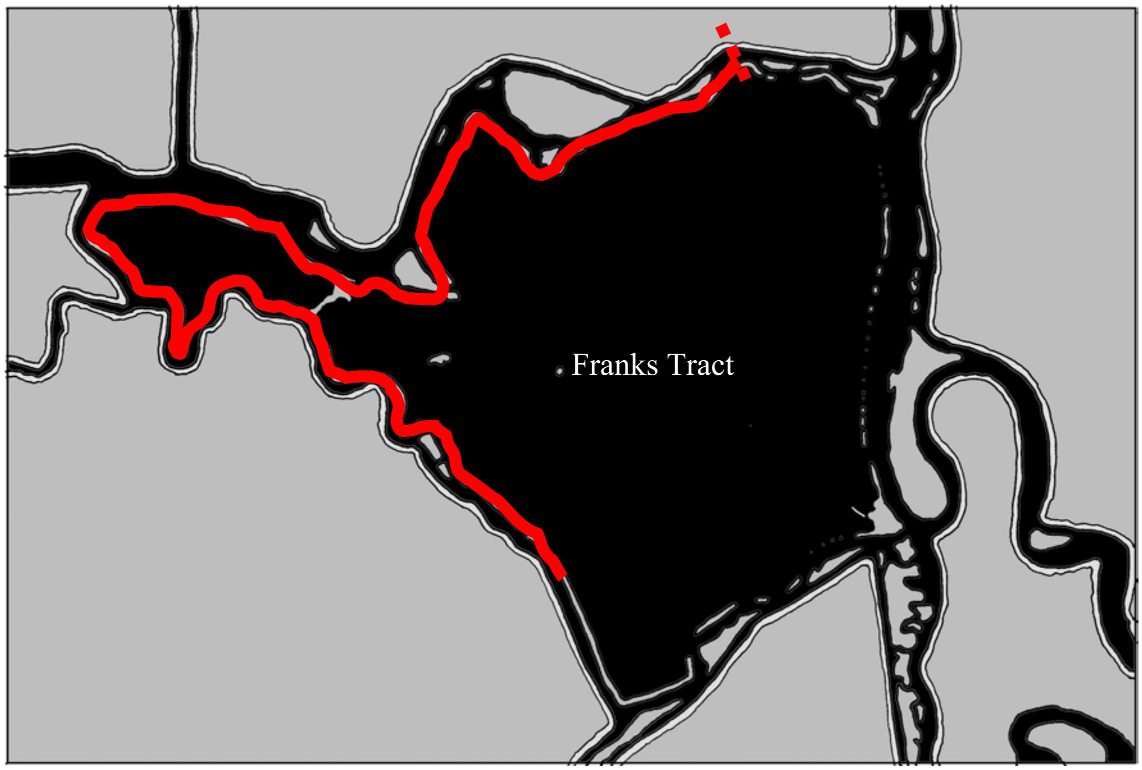


Figure 2.6 – Alternative FT-05

Description: Repair west and north levees and add tide gate on east False River (Figure 2.6).

Table 2.5 Alternative FT-05 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
Water Quality	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
Water Quality	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
Water Quality	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
Water Quality	DOC (at pumps)	?	↑	↓	↓	↑	↑	↓	?	■
Water Quality	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
Ecosystem	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
Ecosystem	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
Ecosystem	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
Ecosystem	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
Recreation/Other	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
Recreation/Other	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■	Beneficial change
■	Neutral change
■	Unbeneficial change

Arrows indicate direction of change

Key points: (From Burau) This alternative is similar to Alternative FT-03 except a tide gate is used in place of a barrier. The tide gate would be operated as described previously. The barrier was purposely placed in False River west of several large breaches to enhance north-south exchange within Franks Tract which could reduce the negative effects of increased residence times within Franks Tract.

Similar to Alternative FT-02, the reduced connectivity is likely to reduce salinity at the pumps slightly. The increased residence time, particularly in western Franks Tract is of concern both for growth of unwanted SAV and potential mercury methlyation. This alternative also blocks key boating access points into and across Franks Tract.

As mentioned by Burau above, this is an improvement on Alternative FT-03 in that it alleviates some of the residence time factors and it also provides boating access when the gate is up. The alternative still blocks several key access points along the north and west Franks Tract levees.

2.3.6. 2.3.6. Alternative FT-06

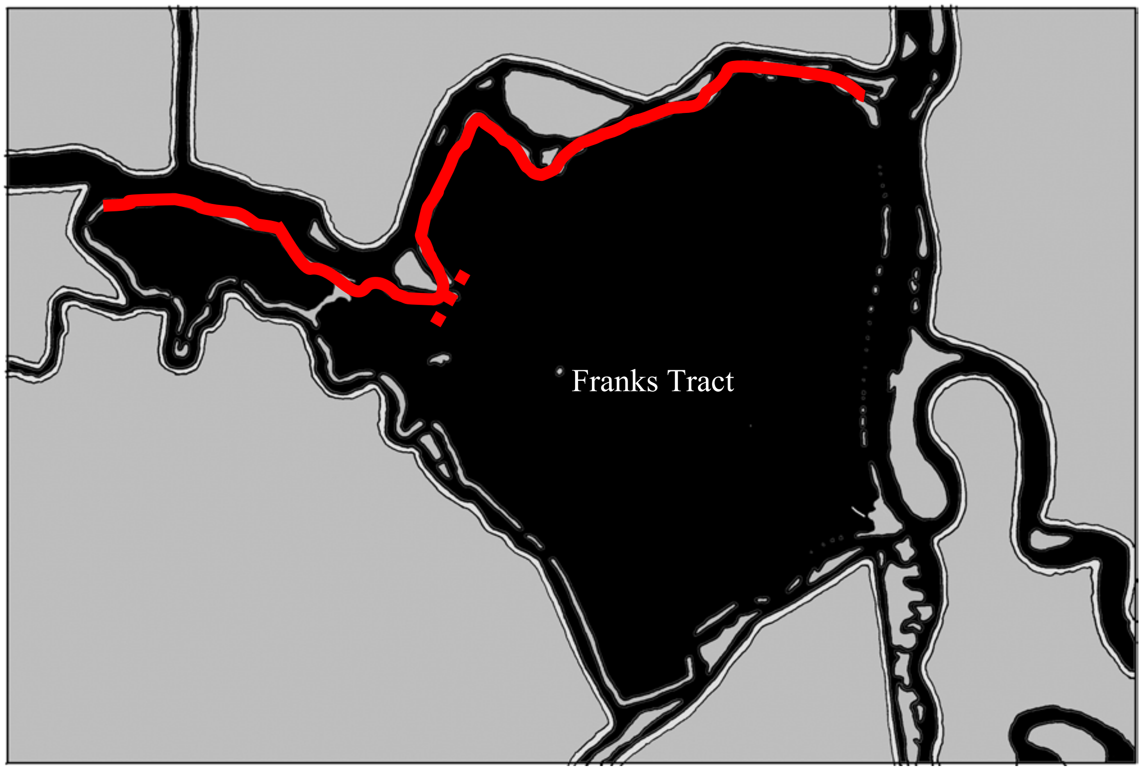


Figure 2.7 – Alternative FT-06

Description: Repair north levees, add tide gates in the main jet and (Figure 2.7).

Table 2.6. Alternative FT-06 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
	DOC (at pumps)	?	↑	↓	↓	↑	↑	↓	?	■
	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■ (green)	Beneficial change
■ (grey)	Neutral change
■ (red)	Unbeneficial change

Arrows indicate direction of change

Key Points: The gates on the nozzle would be operated as described previously. This scenario recognizes the importance of maintaining relatively short residence times in Franks tract to control the spread of *Egeria* and to reduce the possibility of nuisance algal blooms. This particular scenario could be used to "grow carbon" since the gates could be used to control residence times. Moreover, since these gates would remain open most of the year, and closed only on flood tides when operating, boat traffic would not be significantly changed from Franks Tracts existing configuration.

The added gate adds a navigational barrier when in operation.

2.3.7. Alternative FT-07

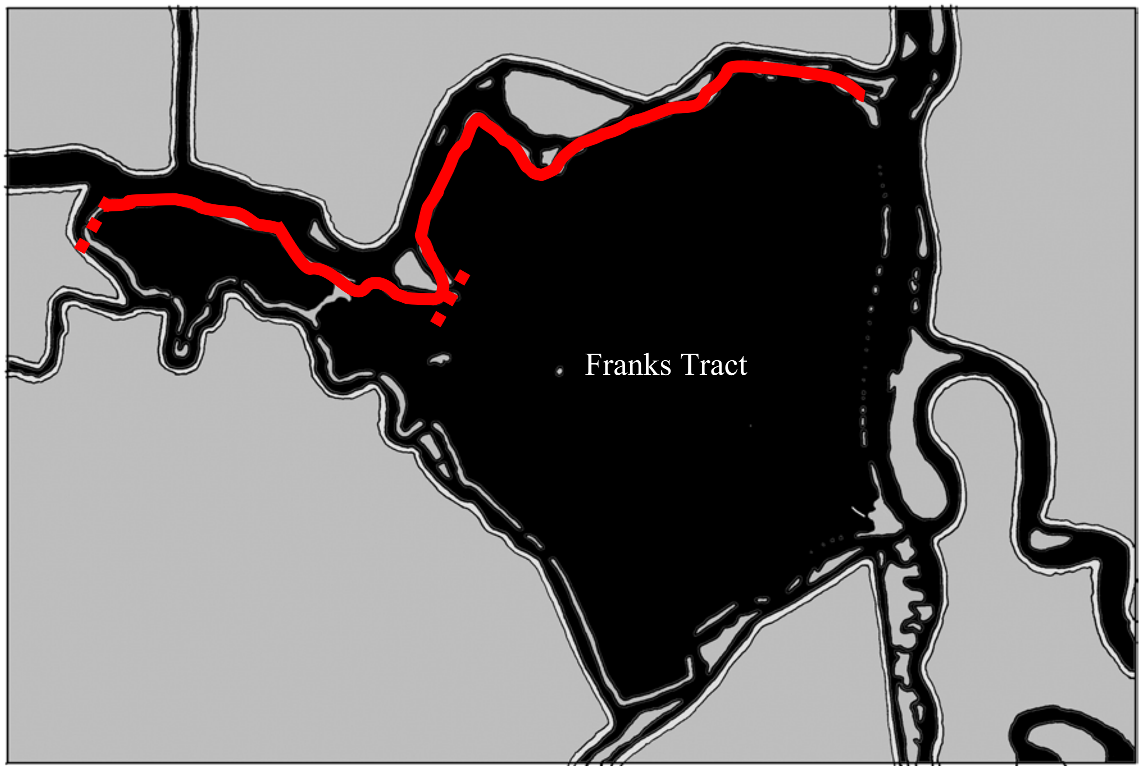


Figure 2.8 – Alternative FT-07

Description: Repair north levees, add tide gates in the main jet and on piper slough (Figure 2.8).

Table 2.7. Alternative FT-07 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
Water Quality	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
Water Quality	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
Water Quality	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
Water Quality	DOC (at pumps)	?	↑	↓	↓	↑	↑	↓	?	■
Water Quality	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
Ecosystem	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
Ecosystem	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
Ecosystem	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
Ecosystem	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
Recreation/Other	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
Recreation/Other	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■ (green)	Beneficial change
■ (gray)	Neutral change
■ (red)	Unbeneficial change

Arrows indicate direction of change

Key Points: This alternative is very similar to FT-06 except that it adds a tide gate on Piper Slough to prevent salinity from intruding into Franks Tract. The gates would be operated as described previously. This scenario recognizes the importance of maintaining relatively short residence times in Franks tract to control the spread of *Egeria* and to reduce the possibility of nuisance algal blooms. This particular scenario could be used to "grow carbon" since the gates could be used to control residence times. Moreover, since these gates would remain open most of the year, and closed only on flood tides when operating, boat traffic would not be significantly changed from Franks Tracts existing configuration.

The added gate adds a navigational barrier when in operation.

2.3.8. Alternative FT-08

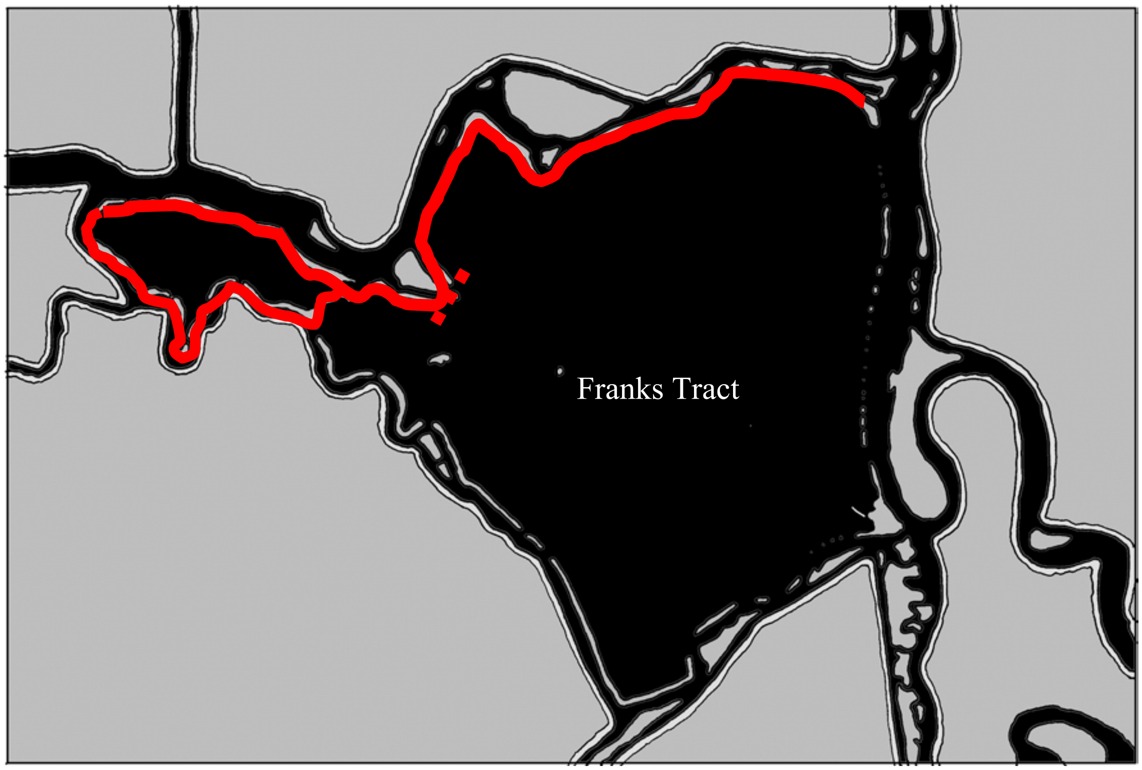


Figure 2.9 – Alternative FT-08

Description: Repair north levees, add tide gates in the main jet and on piper slough (Figure 2.9).

Table 2.8. Alternative FT-08 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
	DOC (at pumps)	?	↑	↓	↓	↑	↑	↓	?	■
	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

- ■ Beneficial change
- ■ Neutral change
- ■ Unbeneficial change

Arrows indicate direction of change

Key Points: This alternative is very similar to FT-07 except that it adds a rebuilds the levee around Little Franks Tract to add roughness and perhaps slow the passage of salinity into Franks Tract without relying on a gate on Piper Slough. The tide gate in the main jet would be operated as described previously. This scenario recognizes the importance of maintaining relatively short residence times in Franks tract to control the spread of *Egeria* and to reduce the possibility of nuisance algal blooms. This particular scenario could be used to "grow carbon" since the gates could be used to control residence times. Moreover, since these gates would remain open most of the year, and closed only on flood tides when operating, boat traffic would not be significantly changed from Franks Tracts existing configuration.

2.3.9. Alternative FT-09

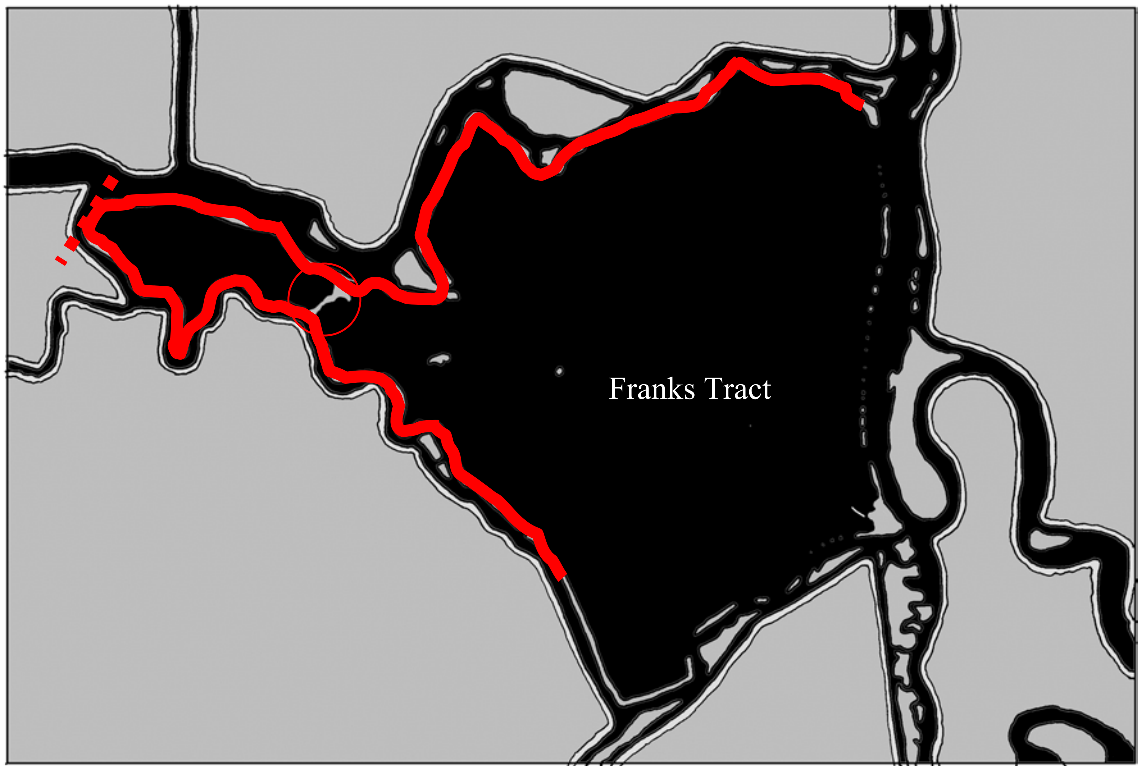


Figure 2.10 – Alternative FT-09

Description: Repair west and north levees and add tide gate on the west side of Little Franks Tract. Remove levee between Franks Tract and Little Franks Tract (Figure 2.10).

Table 2.9. Alternative FT-09 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	■	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
	DOC (at pumps)	↓	↑	↓	↓	↑	↑	↓	?	↑
	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
	Habitat variability	↑	↓	↓	n/a	↓	↑	↓	↑	↑
	Native fishery	↑	↓	↓	↓	↓	↑	↓	↑	↓
	Sport Fishery (black bass, striped bass)	↑	↓	↓	↓	↓	↓	↓	↑	↓
	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

- Beneficial change
- Neutral change
- Unbeneficial change

Arrows indicate direction of change

Key points: (From Burau) This alternative recognizes the importance of controlling residence times in Franks Tract but does so by connecting Little Franks Tract to Franks Tract proper. This scenario requires the removal of the levee that separates Franks Tract from Little Franks Tract and perhaps some dredging of Little Franks Tract to enhance exchange. This levee material could be used as material elsewhere in the project. This scenario has the best chance of growing carbon because Little Franks Tract is narrow and is oriented normal to the prevailing winds, and thus wind mixing will be minimal in this area which could promote phytoplankton growth. Boat access would be available on Franks west side through the tide gate.

This alternative, combined with some marsh restoration element (discussed later in this document) could significantly increase DOC levels in the western Delta and Suisun Marsh, providing great ecological benefits. The methods to do this are untested and the feasibility would be uncertain. Having a single tide gate could also prevent marsh restoration in Little Franks Tract and western Franks Tract by concentrating flows when open and eroding away established marsh.

2.3.10. Alternative FT-10

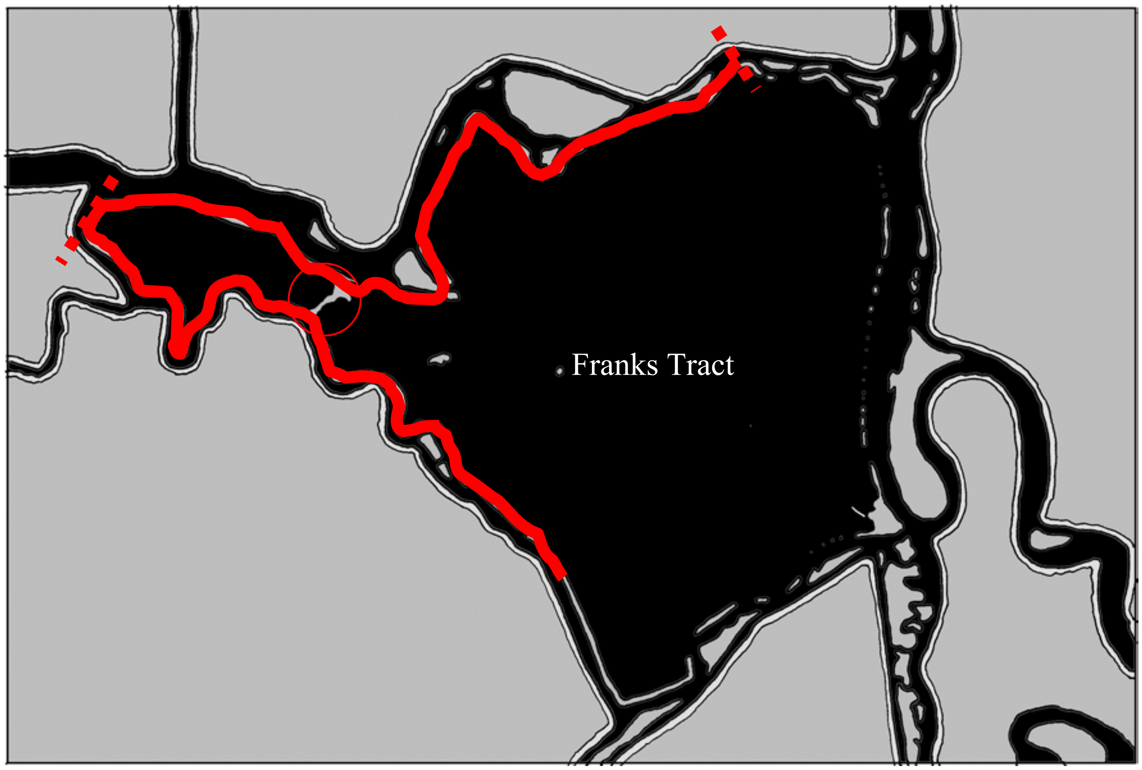


Figure 2.11 – Alternative FT-10

Description: Repair west and north levees and add tide gates on the west side of Little Franks Tract and in E. False River (Figure 2.11).

Table 2.8. Alternative FT-10 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	■	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
	DOC (at pumps)	↓	↑	↓	↓	↑	↑	↓	?	↑
	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
	Habitat variability	↑	↓	↓	n/a	↓	↑	↓	↑	↑
	Native fishery	↑	↓	↓	↓	↓	↑	↓	↑	↓
	Sport Fishery (black bass, striped bass)	↑	↓	↓	↓	↓	↓	↓	↑	↓
	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■ (green)	Beneficial change
■ (grey)	Neutral change
■ (red)	Unbeneficial change

Arrows indicate direction of change

Key points: (From Burau) This alternative is similar to Alternative FT-09 except that it adds (1) additional control of salinity intrusion through False River and (2) greater north/south exchange and thus shorter residence times on Franks Tracts eastern flank.

This alternative recognizes the importance of controlling residence times in Franks Tract but does so by connecting Little Franks Tract to Franks Tract proper. This scenario requires the removal of the levee that separates Franks Tract from Little Franks Tract and perhaps some dredging of Little Franks Tract to enhance exchange. This levee material could be used as material elsewhere in the project. This scenario has the best chance of growing carbon because Little Franks Tract is narrow and is oriented normal to the prevailing winds, and thus wind mixing will be minimal in this area which could promote phytoplankton growth. Boat access would be available on Franks west side through the tide gate.

This alternative, combined with some marsh restoration element (discussed later in this document) could significantly increase DOC levels in the western Delta and Suisun Marsh, providing great ecological benefits. The methods to do this are untested and the feasibility would be uncertain. Having a single tide gate could also prevent marsh restoration in Little Franks Tract and western Franks Tract by concentrating flows when open and eroding away established marsh.

2.3.11. Alternative FT-11

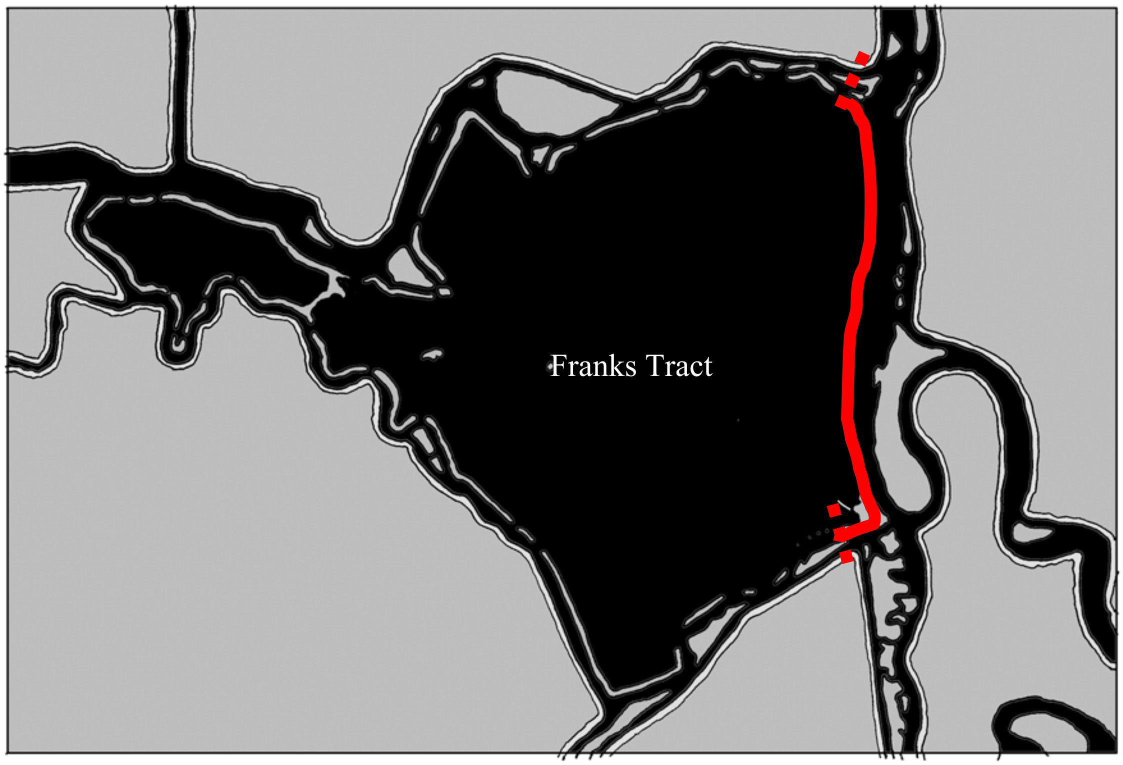


Figure 2.12 – Alternative FT-11

Description: Repair east levees and add tide gates in E. False River and (optionally) in Sand Mound Slough (Figure 2.12).

Table 2.9. Alternative FT-119 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↑	↓	↓	↓	n/a	n/a	↓	?	↑
	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
	DOC (at pumps)	↓	■	↓	↓	↑	↑	↓	?	↓
	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■	Beneficial change
■	Neutral change
■	Unbeneficial change

Arrows indicate direction of change

Key Points: (From Burau) All of the previous alternatives attempt to keep salinity out of Franks Tract, in this alternative, however, salinity is allowed to intrude into Franks Tract but is kept out of the "fresh water corridor" (e.g. Old River) through levee repairs and tide gates on Franks eastern shore. The tide gate on East False River is purposely placed east of the large levee breaches on Franks Tracts northeastern remnant levee to enhance north/south exchange and to decrease residence time within Franks Tract. The tide gate on Sand Mound Slough is placed to control salinity intrusion into the fresh water corridor from Franks Tract through Piper Slough and through the Dutch Slough/Sand Mound Slough complex. This tide gate could significantly reduce specific conductance concentrations at Rock Slough. It is unclear whether the tide gate on Sand Mound Slough is necessary. Under this scenario it is possible that salinities in Franks Tract could be significantly elevated without negatively affecting water supplies. Elevated salinities in Franks Tract could be beneficial to native species, many of which have survival strategies adapted to take advantage of significant seasonal timescale changes in salinity. And, depending on the salt tolerance of Egeria, this configuration could be used to control the spread of this invasive aquatic plant. Dredging through the levee into Franks Tract on Sand Mound Slough south of the tide gate may be necessary to maintain the existing north/south exchange in the interior of Franks Tract which keep residence times relatively low. Also, dredging may be required at the tip of Holland cut to enhance exchange into Sandmound Slough (and by extension into Franks Tracts southern tip).

As Burau states above, the distinction here is that the intent is to keep salt water out of Old River, and allow it in Franks Tract. Hydrodynamic modeling should consider residence time and temperatures in eastern Franks Tract to see if they would increase mercury methylation. This alternative reduces boating access from Franks Tract to Old River, particularly when the gates are in operation. It is unknown if this is preferable to reducing access from points west into Franks Tract.

2.3.12. Alternative FT-12

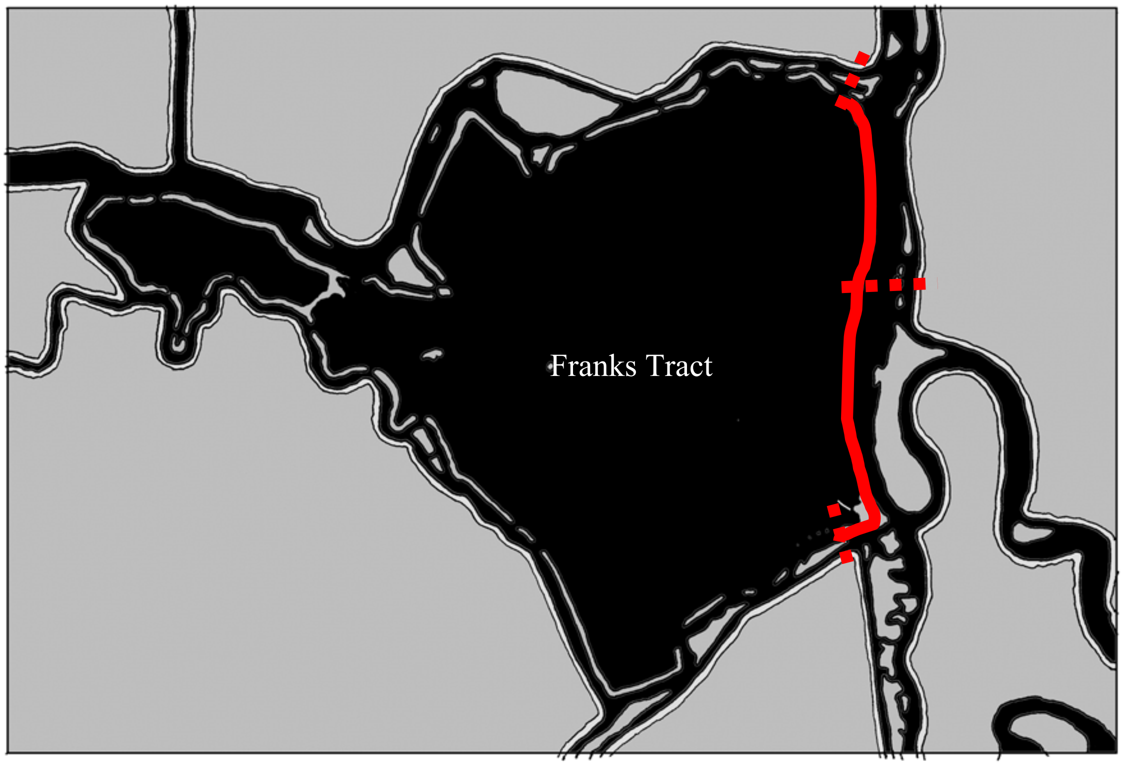


Figure 2.13 – Alternative FT-12

Description: Repair east levees and add tide gates in E. False River, (optionally) in San Mound Slough and tide gate in Old River (Figure 2.13).

Table 2.12. Alternative FT-12 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↑	↓	↓	↓	n/a	n/a	↓	?	↑
	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
	DOC (at pumps)	↓	■	↓	↓	↑	↑	↓	?	↓
	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■ (green)	Beneficial change
■ (grey)	Neutral change
■ (red)	Unbeneficial change

Arrows indicate direction of change

Key points: (From Burau) This is the same as Alternative FT-12 described above, except with the addition of a tide gate on Old River. This tide gate would increase the fresh water exchange between the Mokelumne River and Old River across the San Joaquin and would introduce a strong net flow of fresh water towards the pumps. It is unknown how much salty San Joaquin River water would be entrained as this water moves towards the pumps. This scenario is designed to keep salty water out of the fresh water corridor AND is designed to increase the flow of fresh water towards the pumps. This scenario is the only option that increases the net currents towards the pumps and thus it may be "bad" for fish. However, fish concerns are minimal at the time of year when these gates would be operating. All of the other gate scenarios increase residual circulation through Franks Tract towards Suisun Bay. This scenario locally increases residual circulation towards the pumps.

2.3.13. Alternative FT-13

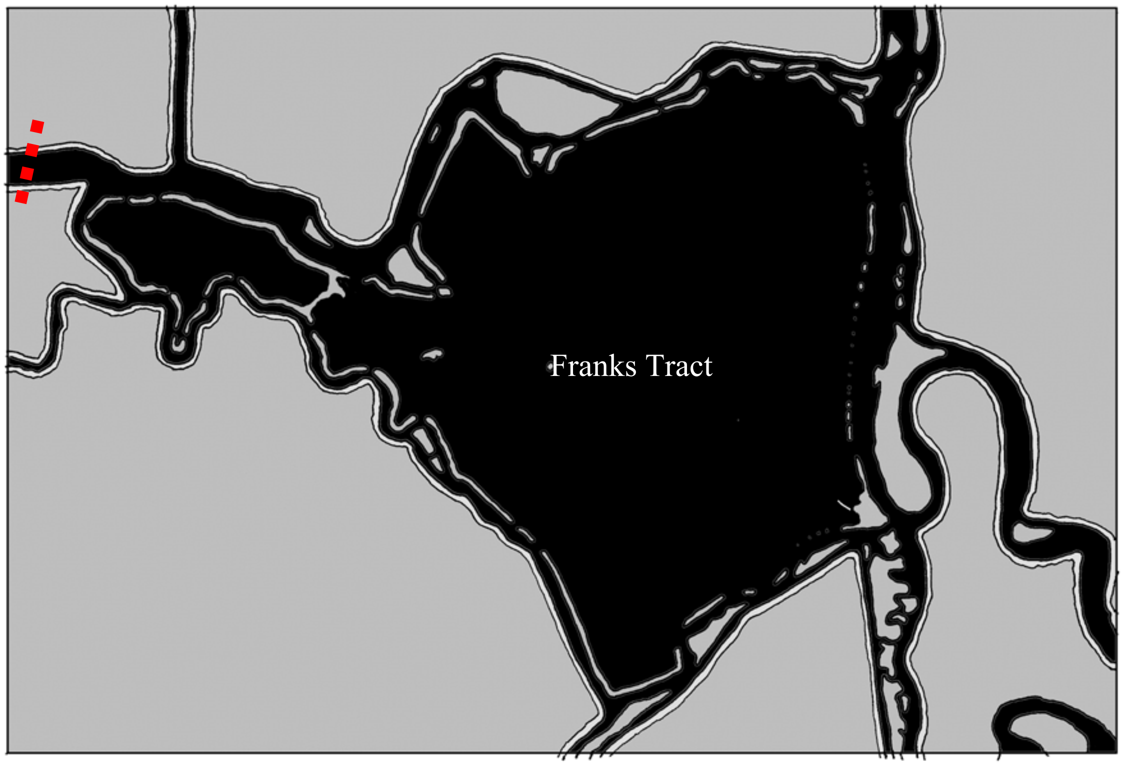


Figure 2.14 – Alternative FT-13

Description: Install tide gate in W. False River (Figure 2.14).

Table 2.13. Alternative FT-13 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
	DOC (at pumps)	↓	↑	↓	↓	↑	↑	↓	?	↓
	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

(green)	Beneficial change
(grey)	Neutral change
(red)	Unbeneficial change

Arrows indicate direction of change

Key points: (From Burau) From an engineering standpoint installation of a single large (spanning roughly 750') tide gate on False River is an elegant solution. Of all the scenarios this approach would likely provide the greatest control over the tides since the tidal flows in E. False River are large (roughly +- 50,000 cfs). Theoretically, net flows on the order of 20,000 cfs (in either direction, depending on how the gate is operated) could be produced in False River using a tide gate placed in this location. This gate would significantly perturb the existing hydrodynamics in the Franks Tract area and would have a significant impact on boat travel while operating, unless a boat lock were installed.

2.3.14. Alternative FT-14

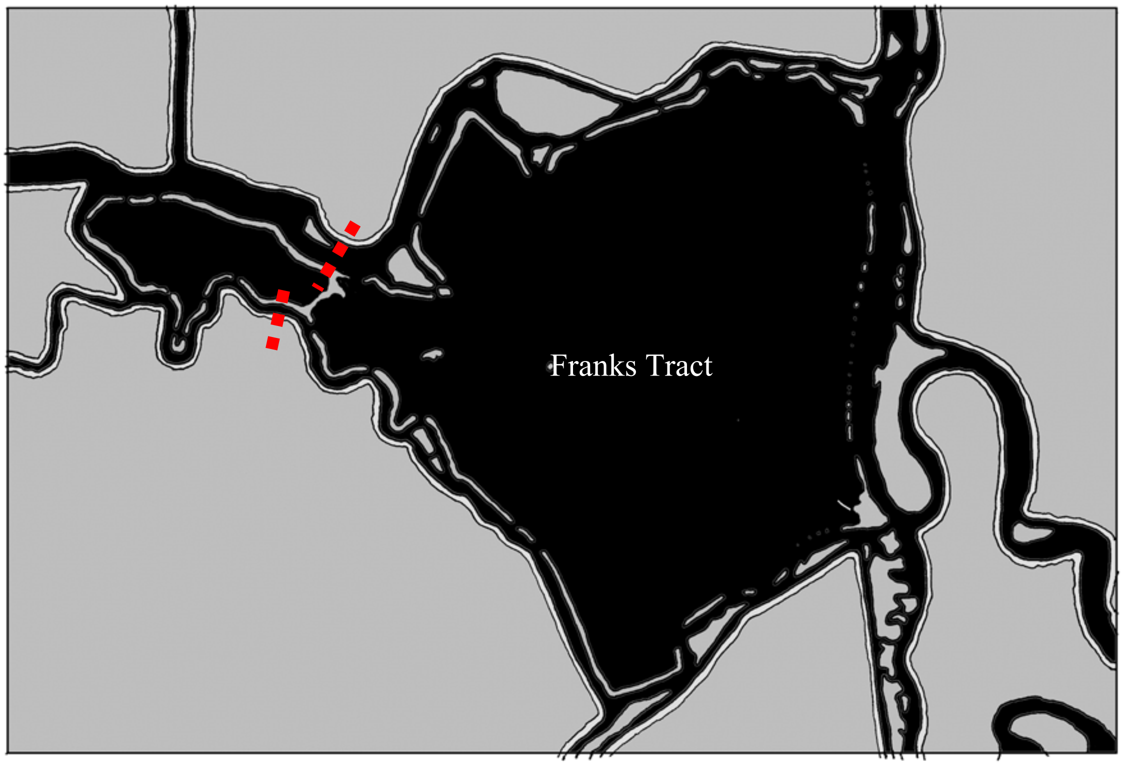


Figure 2.15 – Alternative FT-14

Description: Install tide gates in W. False River and Piper Slough (Figure 2.15).

Table 2.14. Alternative FT-14 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Franks Tract)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
	Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
	DOC (at pumps)	↓	↑	↓	↓	↑	↑	↓	?	↓
	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	↑	↑	↑	?	↑	↑	↑
	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

(green)	Beneficial change
(gray)	Neutral change
(red)	Unbeneficial change

Arrows indicate direction of change

Key points: (From Burau) This alternative is very similar to Alternative FT-13. It controls the flow of salt water into Franks Tract from the west with two smaller gates instead of one larger one. Like FT-13 this approach would likely provide the greatest control over the tides. Theoretically, net flows on the order of 20,000 cfs (in either direction, depending on how the gate is operated) could be produced in False River using tide gates placed in this location. These gates would significantly perturb the existing hydrodynamics in the Franks Tract area. These gates affect boat passage between Franks Tract and Fisherman's Cut and False River when the gates are operable.

2.3.15. Alternative FT-15

Figure 2.16 – Alternative FT-15

Description: Install tide gates in Old River and Holland Cut on either side of Quimby Island (Figure 2.16).

Table 2.15. Alternative FT-15 Screening Matrix

	Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Franks Tract)	Tidal stage	Overall impact
Direction of change	↓	↓	↓	↓	↑	↑	↑	↑	
Salinity (at Franks Tract)	↑	↓	↑	↑	n/a	n/a	↑	?	↑
Salinity (at pumps)	↓	↓	↓	↓	n/a	↑	↓	↑	↓
Temperature	↑	↑	↑	↑	↑	↓	↓	↓	↑
DO	↓	↓	↓	↓	↓	↑	↑	↑	↓
DOC (at pumps)	↓	↑	↓	↓	↑	↑	↓	?	↓
Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Primary productivity	↑	↑	↑	↑	↑	?	↓	↑	↑
Habitat variability	↓	↓	↓	n/a	↓	↑	↑	↑	↓
Native fishery	↓	↓	↓	↓	↓	↑	↑	↑	↓
Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↑	↑	↓
SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↓	↓	↑
Flood Protection	↑	↑	n/a	n/a	n/a	n/a	■	↓	↑

Legend

■ (green)	Beneficial change
■ (grey)	Neutral change
■ (red)	Unbeneficial change

Arrows indicate direction of change

Key Points: Alternative FT-15 works by preventing Franks Tract salinity from entering the south Delta. Franks Tract is allowed to get salty, but the connectivity between Franks Tract and the south Delta pumps is severed by a pair of operable gates on either side of Quimby Island. This alternative, commonly called the Cox Alternative, has been considered for many years as a viable means to reduce salinity in the south Delta. It is likely to have a significant impact on salinity at the pumps. When in operation, the gates eliminate boat passage from points south to Franks Tract.

2.3.16. Alternative BB-01

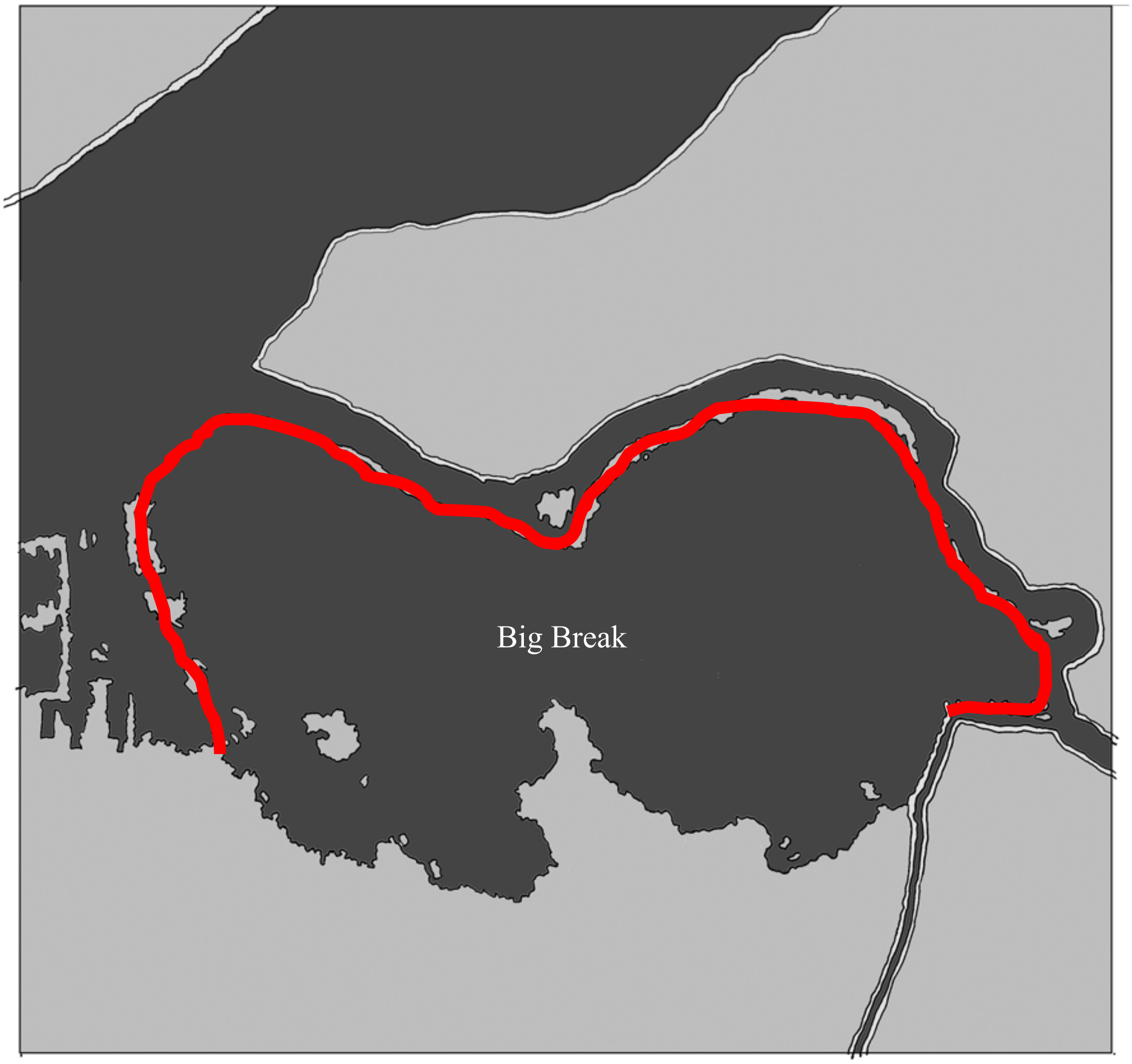


Figure 2.17 – Alternative BB-01

Description: Repair Big Break levees and close off Big Break.

Table 2.16. Alternative BB-01 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Big Break)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
	Effect on:									
Water Quality	Salinity (at Big Break)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
Water Quality	Salinity (at pumps)	■	■	↓	↓	n/a	↑	■	■	■
Water Quality	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
Water Quality	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
Water Quality	DOC (at pumps)	■	■	■	■	■	■	■	?	■
Water Quality	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	■	↑	↑	↑	↑	?	↑	↑	↑
Ecosystem	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
Ecosystem	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
Ecosystem	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
Ecosystem	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
Recreation/Other	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
Recreation/Other	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

- Beneficial change
- Neutral change
- Unbeneficial change

Arrows indicate direction of change

Key Points: This alternative repairs the levees around Big Break to isolate the interior from the Delta. This would reduce tidal trapping and pumping caused by Big Break but would also increase tidal excursion east along Dutch Slough. The two effects would likely cancel each other out. Experts on delta hydraulics indicate that isolating Big Break is too small an intervention and too far west in the Delta to have a significant effect on salinity levels in the south Delta. Most of the salinity intrusion into Franks Tract and the south Delta would still occur through False River.

The loss of connectivity in between Big Break and the Delta would reduce boat access into Big Break, though this alternative would not block the Big Break marina.

Leaving the interior as a shallow, isolated waterbody or even pumping it out would create less desirable habitat types than currently exist.

2.3.17. Alternative BB-02

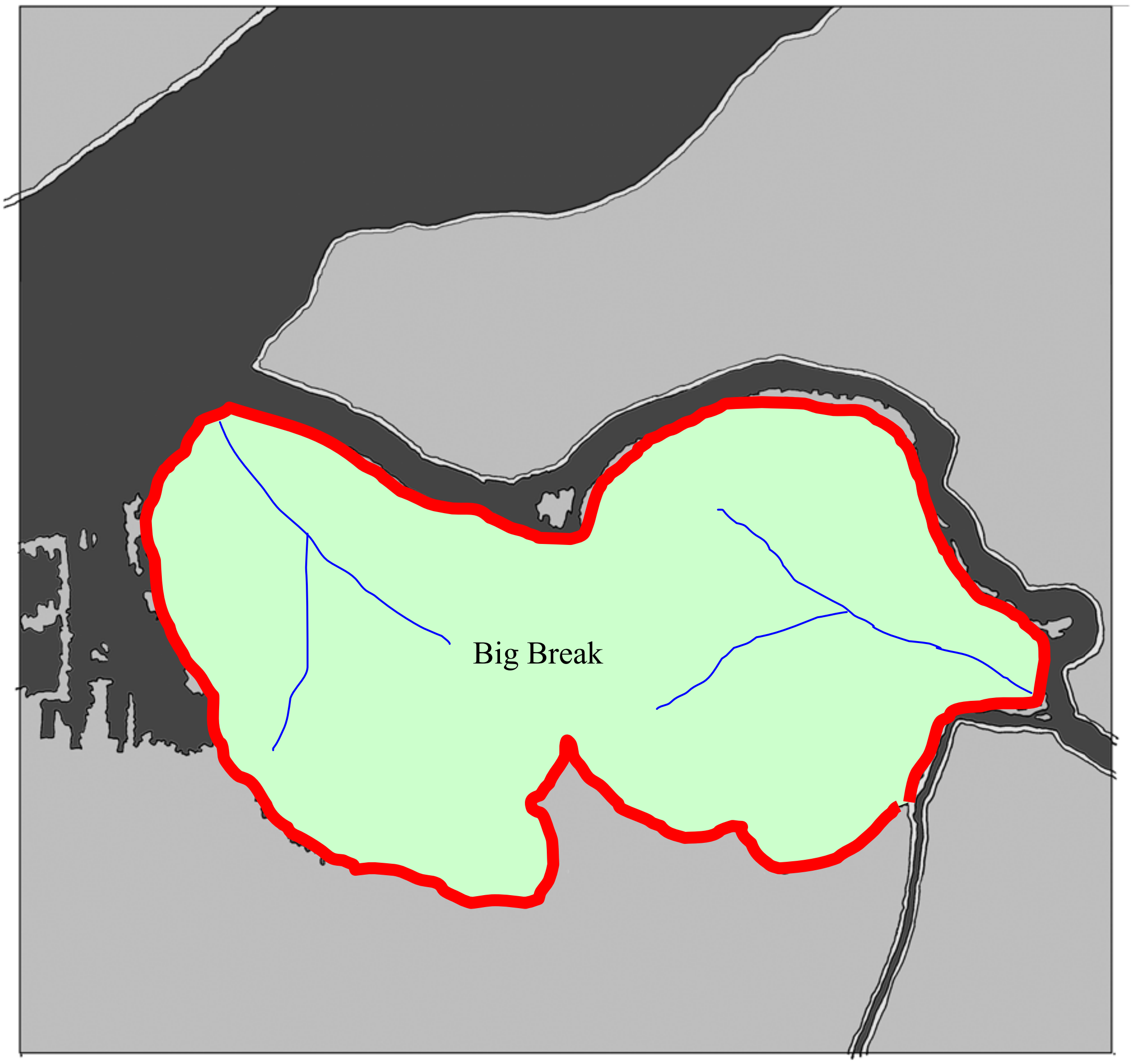


Figure 2.18 – Alternative BB-02

Description: Repair Big Break levees and restore Big Break to tidal marsh.

Table 2.17. Alternative BB-02 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Big Break)	Tidal stage	Overall impact
	Direction of change	↓	↑	↓	↓	↓	↑	↓	↑	
	Effect on:									
Water Quality	Salinity (at Big Break)	■	↓	↓	↓	n/a	n/a	↓	?	↓
	Salinity (at pumps)	■	■	↓	↓	n/a	↑	■	■	■
	Temperature	■	↓	↑	↑	↓	↓	↑	↓	↓
	DO	■	↑	↓	↓	↑	↑	↓	↑	↑
	DOC (at pumps)	■	■	■	■	■	■	■	?	■
	Mercury methylation	n/a	?	?	?	↓	?	?	?	?
Ecosystem	Primary productivity	■	↑	↑	↑	↓	?	↑	↑	↑
	Habitat variability	↑	↑	↓	n/a	↑	↑	↓	↑	↑
	Native fishery	↑	↑	↓	↓	↑	↑	↓	↑	↑
	Sport Fishery (black bass, striped bass)	↑	↑	↓	↓	↑	↓	↓	↑	↑
	SAV	n/a	↓	n/a	n/a	↓	↓	↑	?	↓
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

- Beneficial change
- Neutral change
- Unbeneficial change

Arrows indicate direction of change

Key Points: This alternative repairs the levees around Big Break and rebuilds the interior of Big Break to create tidal marsh. This would tidal trapping and pumping caused by Big Break but would also decrease the tidal prism in Big Break and increase tidal excusion east along Dutch Slough. The two effects would likely cancel each other out. Experts on delta hydraulics indicate that restoring tidal marsh in Big Break is too small an intervention and too far west in the Delta to have a significant effect on salinity levels in the south Delta. Most of the salinity intrusion into Franks Tract and the south Delta would still occur through False River.

The loss of connectivity in between Big Break and the Delta would reduce boat access into Big Break, though this alternative would not block the Big Break marina. The creation of tidal marsh would increase passive recreation such as wildlife viewing.

The creation of tidal marsh on Big Break would benefit native and desirable species.

2.3.18. Alternative BB-03

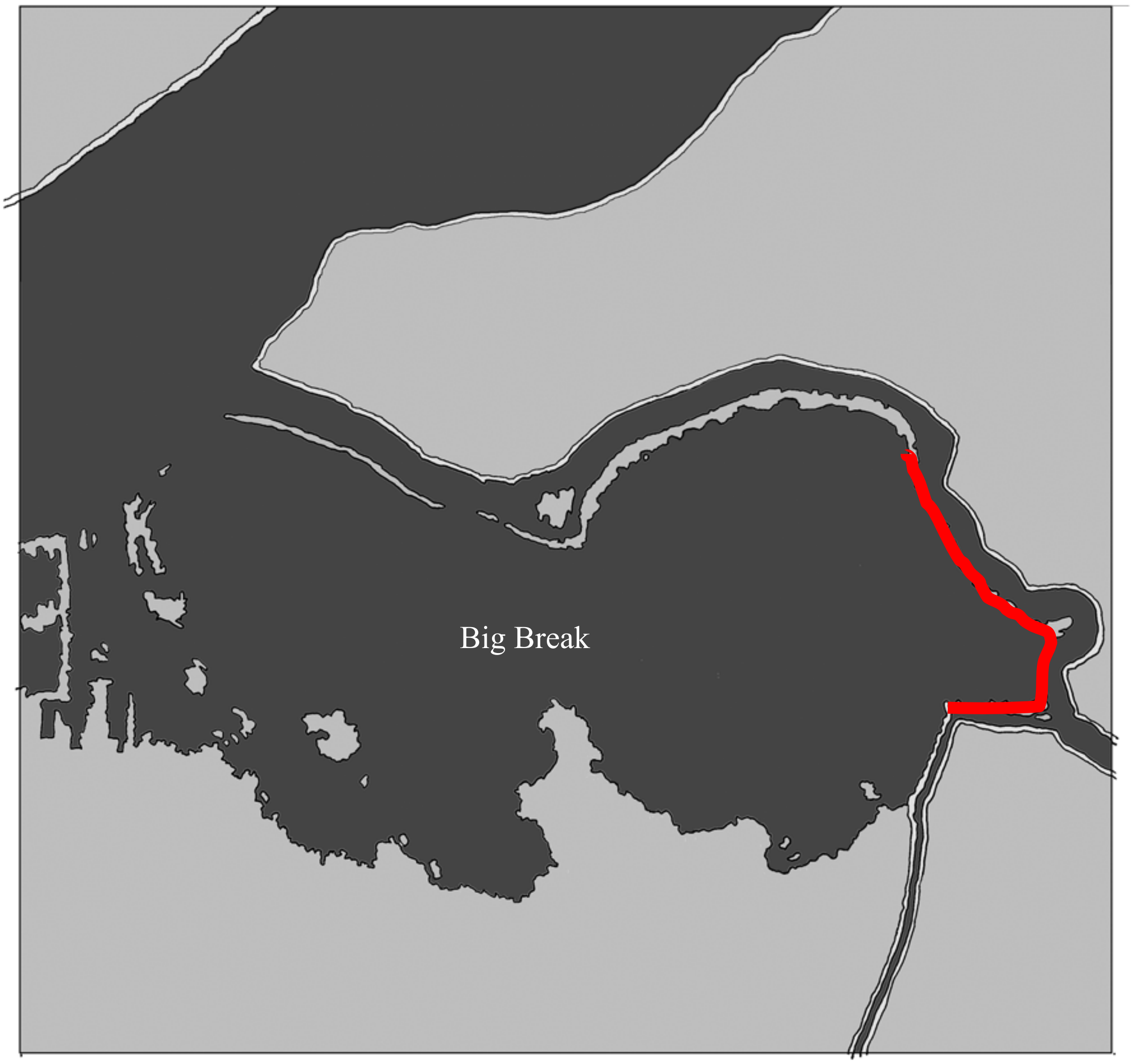


Figure 2.19 – Alternative BB-03

Description: Repair northeast levee of Big Break.

Table 2.18. Alternative BB-03 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Big Break)	Tidal stage	Overall impact
	Direction of change	⬇	■	⬇	⬇	■	■	■	■	
	Effect on:									
Water Quality	Salinity (at Big Break)	⬆	■	⬆	⬆	n/a	n/a	■	?	⇧
Water Quality	Salinity (at pumps)	⬇	■	■	■	n/a	■	■	■	□
Water Quality	Temperature	■	■	■	■	■	■	■	■	□
Water Quality	DO	■	■	■	■	■	■	■	■	□
Water Quality	DOC (at pumps)	■	■	■	■	■	■	■	?	□
Water Quality	Mercury methylation	n/a	?	?	?	■	?	?	?	?
Ecosystem	Primary productivity	■	■	■	■	■	?	■	■	□
Ecosystem	Habitat variability	⬆	■	■	n/a	■	■	■	■	□
Ecosystem	Native fishery	⬆	■	■	■	■	■	■	■	□
Ecosystem	Sport Fishery (black bass, striped bass)	⬆	■	■	■	■	■	■	■	□
Ecosystem	SAV	n/a	■	n/a	n/a	■	■	■	?	□
Recreation/Other	Boating Access	■	n/a	n/a	n/a	n/a	n/a	n/a	■	□
Recreation/Other	Island/levee stability	⬆	■	n/a	n/a	n/a	n/a	■	■	⬆ (green)
Recreation/Other	Flood Protection	■	■	n/a	n/a	n/a	n/a	■	■	□

Legend

■ (green)	Beneficial change
□ (gray)	Neutral change
■ (red)	Unbeneficial change

Arrows indicate direction of change

Key Points: Repairing the northeast levee of Big Break could reduce the interaction between Big Break and Dutch Slough (and by extension, Franks Tract). The levee would reduce tidal pumping from Big Break. Experts on delta hydraulics indicate that such an intervention in Big Break is too small and too far west in the Delta to have a significant effect on salinity levels in the south Delta. Most of the salinity intrusion into Franks Tract and the south Delta would still occur through False River.

Reconstructing the northeast levee would have negligible effects on boating access and habitat in Big Break.

2.3.19. Alternative BB-04

Figure 2.20 – Alternative BB-04

Description: Tidal gate on Dutch Slough.

Table 2.19. Alternative BB-04 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Big Break)	Tidal stage	Overall impact
	Direction of change	↓	↑	↓	↓	■	↓	■	↑	
	Effect on:									
Water Quality	Salinity (at Big Break)	↑	↑	↑	↑	n/a	n/a	■	?	↑
	Salinity (at pumps)	■	■	↓	↓	n/a	↓	■	■	□
	Temperature	↑	↓	↑	↑	■	↓	■	↓	□
	DO	↓	↑	↓	↓	■	↑	■	↑	□
	DOC (at pumps)	■	■	■	■	■	■	■	?	□
	Mercury methylation	n/a	?	?	?	■	?	?	?	?
Ecosystem	Primary productivity	■	■	↑	↑	■	?	■	↑	↑
	Habitat variability	↑	↑	↓	n/a	■	↓	■	↑	□
	Native fishery	↓	↑	↓	↓	■	↓	■	↑	□
	Sport Fishery (black bass, striped bass)	↓	↑	↓	↓	■	↓	■	↑	□
	SAV	n/a	↓	n/a	n/a	■	■	■	?	□
Recreation/Ot	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	■	n/a	n/a	n/a	n/a	■	↓	□
	Flood Protection	↑	■	n/a	n/a	n/a	n/a	■	↓	□

Legend

- ■ Beneficial change
- □ Neutral change
- ■ Unbeneficial change

Arrows indicate direction of change

Key Points: A tidal gate on Dutch Slough would reduce the interaction between Franks Tract and Big Break, preventing tidal trapping and pumping caused by Big Break from impacting Franks Tract and the south Delta pumps. Experts on delta hydraulics indicate that a gate on Dutch Slough in Big Break is too small an intervention and too far west in the Delta to have a significant effect on salinity levels in the south Delta. Most of the salinity intrusion into Franks Tract and the south Delta would still occur through False River.

The tidal gate would impair boat access along Dutch Slough when in operation, unless equipped with a boat lock. The gate would have negligible impact on desired habitat.

2.3.20. Alternative SL-01

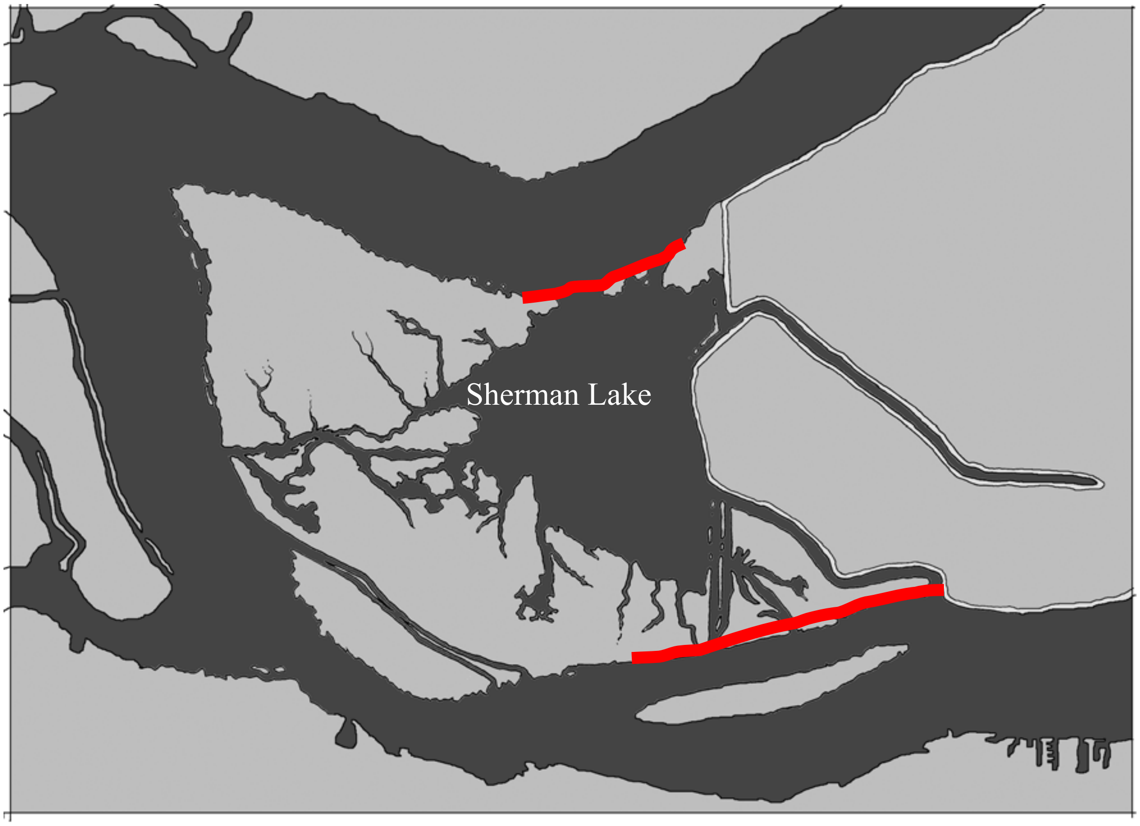


Figure 2.21 – Alternative SL-01

Description: Repair Sherman Lake levees and close off Sherman Lake.

Table 2.20. Alternative SL-01 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Sherman Lake)	Tidal stage	Overall impact
	Direction of change	↓	↓	↓	↓	↑	↑	↓	↑	
Water Quality	Salinity (at Sherman Lake)	↓	↓	↓	↓	n/a	n/a	↓	?	↓
Water Quality	Salinity (at pumps)	■	■	↓	↓	n/a	↑	■	■	■
Water Quality	Temperature	↑	↑	↑	↑	↑	↓	↑	↓	↑
Water Quality	DO	↓	↓	↓	↓	↓	↑	↓	↑	↓
Water Quality	DOC (at pumps)	■	■	■	■	■	■	■	■	■
Water Quality	Mercury methylation	n/a	↑	?	?	↑	?	?	?	?
Ecosystem	Primary productivity	↑	↑	■	■	↑	?	↓	↑	↑
Ecosystem	Habitat variability	↓	↓	↓	n/a	↓	↑	↓	↑	↓
Ecosystem	Native fishery	↓	↓	↓	↓	↓	↑	↓	↑	↓
Ecosystem	Sport Fishery (black bass, striped bass)	↓	↓	↓	↓	↓	↓	↓	↑	↓
Ecosystem	SAV	n/a	↑	n/a	n/a	↑	↓	↑	?	↑
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
Recreation/Other	Island/levee stability	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑
Recreation/Other	Flood Protection	↑	↑	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■ (green)	Beneficial change
■ (grey)	Neutral change
■ (red)	Unbeneficial change

Arrows indicate direction of change

Key Points: Repairing the levees along Sherman Lake would eliminate tidal trapping and pumping. Sherman Lake also serves as a short cut for fresh water from the Sacramento to enter into the San Joaquin. The loss of this fresh water from the Sacramento would off set or even out weigh any salinity improvement from eliminating tidal trapping and pumping in Sherman Lake. Experts on delta hydraulics indicate that repairing levees along Sherman Lake is too small an intervention and too far west in the Delta to have a significant effect on salinity levels in the south Delta. Most of the salinity intrusion into Franks Tract and the south Delta would still occur through False River.

Levee repair along Sherman Lake would eliminate boat access into Sherman Lake.

Sherman Lake is operating reasonably well as habitat in its current state. Repairing the levees and isolating it from the surrounding Delta would likely have a negative impact on desired habitat.

2.3.21. Alternative SL-02

Figure 2.22 – Alternative SL-02

Description: Repair Sherman Lake levees and restore Sherman Lake to tidal marsh.

Table 2.21. Alternative SL-01 Screening Matrix

		Connectivity	Velocity gradients	Tidal trapping	Tidal pumping	Residence time	Length of tidal excursion	Tidal prism (in Sherman Lake)	Tidal stage	Overall impact
	Direction of change	⬇	↑	↓	↓	↓	↑	⬇	↑	
Water Quality	Salinity (at Sherman Lake)	⬇	↑	↓	↓	n/a	n/a	↓	?	⇩
	Salinity (at pumps)	■	■	↓	↓	n/a	↑	■	■	■
	Temperature	⬆	↓	↑	↑	↓	↓	↑	↓	⇧
	DO	⬇	↑	↓	↓	↑	↑	↓	↑	⇩
	DOC (at pumps)	■	■	■	■	■	■	■	■	■
	Mercury methylation	n/a	⬆	?	?	⬆	?	?	?	?
Ecosystem	Primary productivity	⬆	↑	↑	↑	↓	?	↓	↑	⬆
	Habitat variability	⬆	⬆	↓	n/a	↑	↑	↓	↑	⬆
	Native fishery	⬆	⬆	↑	↑	↑	↑	↓	↑	⬆
	Sport Fishery (black bass, striped bass)	⬆	⬆	↑	↑	↑	↑	↓	↑	↑
	SAV	n/a	⬇	n/a	n/a	⬇	↓	↓	?	↓
Recreation/Other	Boating Access	↓	n/a	n/a	n/a	n/a	n/a	n/a	↑	↓
	Island/levee stability	↑	↓	n/a	n/a	n/a	n/a	↑	↓	↑
	Flood Protection	↑	↓	n/a	n/a	n/a	n/a	↑	↓	↑

Legend

■ (green)	Beneficial change
■ (grey)	Neutral change
■ (red)	Unbeneficial change

Arrows indicate direction of change

Repairing the levees along Sherman Lake and creating tidal marsh would eliminate tidal trapping and pumping. Sherman Lake also serves as a short cut for fresh water from the Sacramento to enter into the San Joaquin. The loss of this fresh water from the Sacramento would off set or even out weigh any salinity improvement from eliminating tidal trapping and pumping in Sherman Lake. Experts on delta hydraulics indicate that repairing levees and restoring tidal marsh in Sherman Lake is too small an intervention and too far west in the Delta to have a significant effect on salinity levels in the south Delta. Most of the salinity intrusion into Franks Tract and the south Delta would still occur through False River.

Levee repair and tidal marsh creation in Sherman Lake would eliminate boat access into Sherman Lake. It could increase passive recreation such as wildlife viewing.

The creation of additional tidal marsh habitat in Sherman Lake would benefit native and desirable species.

2.4. Summary of Key Issues

Table 2.22. Summary Screening Matrix (Franks Tract)

	Alternative	FT-01	FT-02	FT-03	FT-04	FT-05	FT-06	FT-07	FT-08
	Effect on:								
Water Quality	Salinity (at Franks Tract)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)
Water Quality	Salinity (at pumps)	■ (gray)	↓ (green)	↓ (green)	■ (gray)	↓ (green)	↓ (green)	↓ (green)	↓ (green)
Water Quality	Temperature	↑ (gray)	↑ (gray)	↑ (gray)	↑ (gray)	↑ (gray)	↑ (gray)	↑ (gray)	↑ (gray)
Water Quality	DO	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)
Water Quality	DOC (at pumps)	↓ (green)	■ (gray)	■ (gray)	↑ (red)	■ (gray)	■ (gray)	■ (gray)	■ (gray)
Water Quality	Mercury methylation	?	?	?	?	?	?	?	?
Ecosystem	Primary productivity	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (red)	↑ (red)	↑ (red)
Ecosystem	Habitat variability	↓ (red)	↓ (red)	↓ (red)	↑ (green)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Ecosystem	Native fishery	↓ (red)	↓ (red)	↓ (red)	↑ (green)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Ecosystem	Sport Fishery (black bass, striped bass)	↓ (red)	↓ (red)	↓ (red)	↑ (green)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Ecosystem	SAV	↑ (red)	↑ (red)	↑ (red)	↓ (green)	↑ (red)	↑ (red)	↑ (red)	↑ (red)
Recreation/Other	Boating Access	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Recreation/Other	Island/levee stability	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Recreation/Other	Flood Protection	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)

	Alternative	FT-09	FT-10	FT-11	FT-12	FT-13	FT-14	FT-15
	Effect on:							
Water Quality	Salinity (at Franks Tract)	↓ (gray)	↓ (gray)	↑ (gray)	↑ (gray)	↓ (gray)	↓ (gray)	↑ (gray)
Water Quality	Salinity (at pumps)	↓ (green)	↓ (green)	↓ (green)	↓ (green)	↓ (green)	↓ (green)	↓ (green)
Water Quality	Temperature	↑ (gray)	↑ (gray)	↑ (gray)	↑ (gray)	↑ (gray)	↑ (gray)	↑ (gray)
Water Quality	DO	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)	↓ (gray)
Water Quality	DOC (at pumps)	↑ (red)	↑ (red)	↓ (green)	↓ (green)	↓ (green)	↓ (green)	↓ (green)
Water Quality	Mercury methylation	?	?	?	?	?	?	?
Ecosystem	Primary productivity	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Ecosystem	Habitat variability	↑ (green)	↑ (green)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Ecosystem	Native fishery	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Ecosystem	Sport Fishery (black bass, striped bass)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Ecosystem	SAV	↑ (red)	↑ (red)	↑ (red)	↑ (red)	↑ (red)	↑ (red)	↑ (red)
Recreation/Other	Boating Access	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Recreation/Other	Island/levee stability	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Recreation/Other	Flood Protection	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)

Legend

■ (green)	Beneficial change
■ (gray)	Neutral change
■ (red)	Unbeneficial change

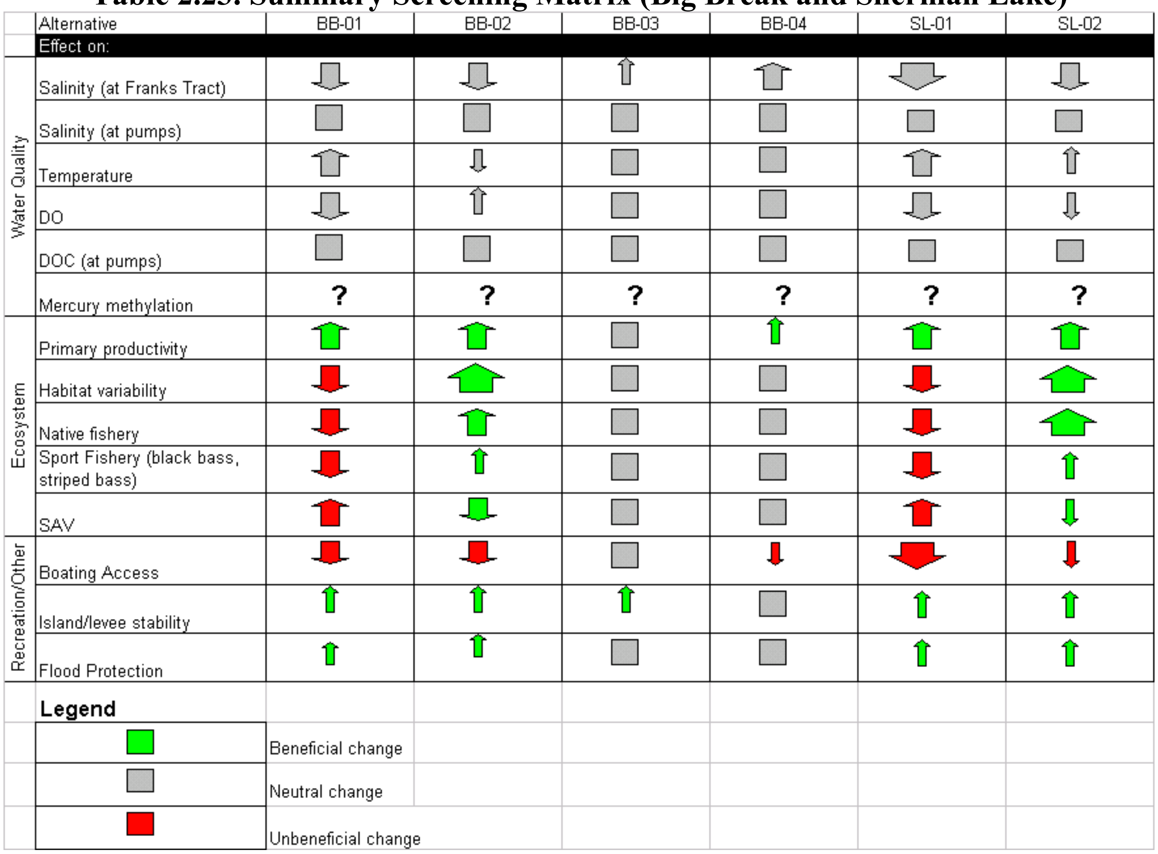
Table 2.22 summarizes the qualitative impacts of the various alternatives on key water quality, ecosystem, and recreational parameters in Franks Tract. The fifteen alternatives screened fall into five categories: 1) hydraulic disconnection (Alternatives 1 and 4); 2) North and levee repair (Alternatives 2, 3, 5, 6, 7, 8, 9 and 10); 3) East levee repairs

(Alternatives 11 and 12); and 4) False River gates (Alternative 13 and 14); Quimby Island gates (Alternative 15).

Alternatives 1 and 4 seem to provide very little, if any salinity benefits, and the amount of fill required and impacts on current recreation make them unlikely candidates. One of the two should be modeled as a benchmark to better understand the function of Franks Tract in salinity dynamics in the Delta.

In category 2, Alternatives 2, 6, 7 and 8 are probably the most likely for further consideration. They represent the most realistic, arguably feasible, alternatives and also represent a reasonable variation on the theme of north levee repair. In category 3, Alternative 11 or 12 are reasonably similar that either could be modeled and analyzed as a proxy for the entire category. In category 4, both gate options should be considered for further analysis. In category 5, the single alternative in that category should be further analyzed in the feasibility report.

Table 2.23. Summary Screening Matrix (Big Break and Sherman Lake)



As none of the Big Break or Sherman Lake alternatives have significant impact on salinity at the pumps, these alternatives should not be analyzed further in the feasibility report.

3. Ecosystem Elements

3.1. Summary of Ecosystem Restoration Elements

3.1.1. Tidal Marsh Restoration Element

3.1.1.1. Conceptual Model

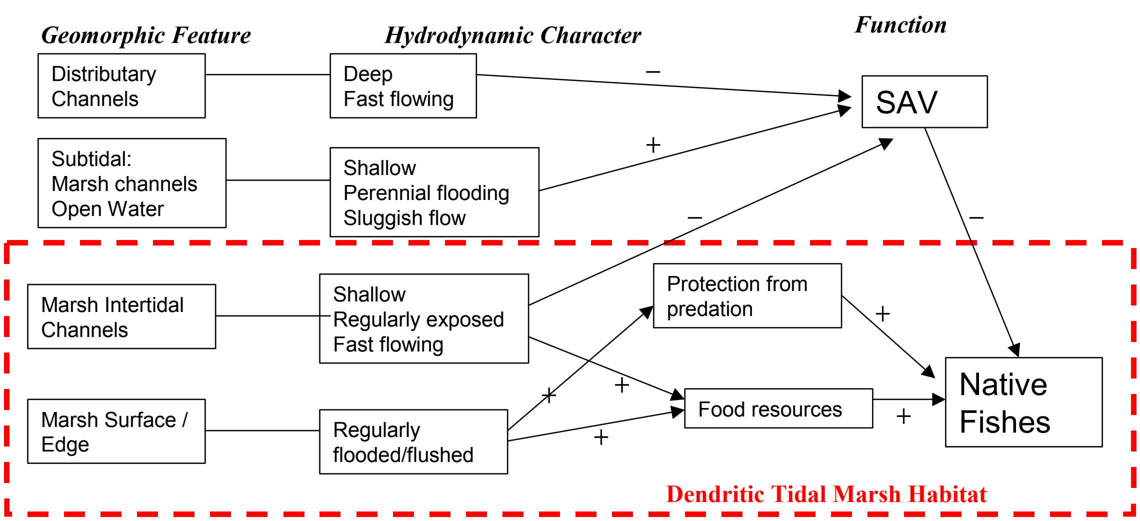
The purpose of restoring tidal marsh is to reduce and reverse the decline of native fishes in the Delta. The reduction in quantity, quality, and diversity of habitat for native fishes has likely contributed to the listing of several species that are found in the Delta during parts of their life cycles. The ecosystem approach to species conservation adopted by CALFED calls for sustaining and enhancing the fundamental ecological structures and processes that support the species. *Thus, the objective of this element is to provide dendritic tidal marsh habitat with attributes that will benefit native, at-risk species, and discourage attributes (i.e., non-native SAV) that do not.*

The conceptual model underlying this restoration element is the link between the decline in natural dendritic intertidal marsh habitat, which historically dominated the Delta (Atwater, 1980), and the decline in native, at-risk species, including delta smelt, splittail, chinook salmon, and steelhead rainbow trout utilizing the Bay-Delta. The presence of extensive dendritic intertidal marsh habitat at a time when native, at-risk species maintained healthy populations implies that habitat restoration will likely benefit the native species that coevolved over the development of the historic Delta.

The Delta has changed dramatically from pre-historic conditions. Physical changes such as the creation of large shallow open water areas associated with flooded islands have created a large habitat type that did not formerly exist. Biological changes such as the invasion of numerous exotic species have also altered conditions for native species. Many of these species, particularly submerged aquatic vegetation (SAV), thrive in the shallow water areas characteristic of flooded Islands. Recent studies (Grimaldo et al., 2002) note an association between subtidal areas, frequently dominated by SAV, and non-native fishes that consume native fishes, or may displace or out-compete them.

The project proposes to convert the shallow water areas associated with flooded islands into dendritic, intertidal marsh. The conceptual basis for this proposal is outlined in Figure 3.1. Tule vegetation characteristic of fresh water tidal marsh readily colonizes marsh areas between –2 and +3 MLLW and thus preempts establishment of noxious SAV. The intertidal marsh plain drains and floods on daily cycles and discourages the establishment of territorial non-native species, but still provides habitat for transitory native species who have evolved to use the marsh during high water periods. Dendritic channel networks carry water and nutrients to and from the site and provide native fish with access to the marsh. These habitats prove beneficial only if they are directly accessible to native fish via SAV free water. If native fish must traverse dense beds of SAV in order to access the marsh, they are likely to succumb to predation or otherwise fail to beneficially utilize the marsh. Thus, an important landscape component of the conceptual model is that active distributary or slough channels also exhibit conditions that are unsuitable (too deep or too turbid) for SAV growth. Furthermore, we assume that relatively large restoration patch sizes of approximately 100-200 acres are preferable for native fish species and are necessary to support a high order dendritic channel network.

Figure 3.1: Conceptual Model for Tidal Marsh Restoration (from Delta Habitat Group)



3.1.1.2. Tidal Marsh Restoration on Flooded Islands

The most obvious method for converting areas of shallow water to tidal marsh is to fill large areas of flooded islands to intertidal habitat. Donlan Island on the southwestern edge of Sherman Island is an example of tidal marsh habitat created by deposition of dredger materials. Large areas of the Donlan marsh, however, have not been colonized by tule vegetation. This could be due to a combination of the fill elevation (less than MLLW), sand substrate, high velocities through the restored area, and lack of active tule planting. These considerations and the associated evolution of the Donlan site could provide useful insights in the subsequent design and construction of tidal marsh in other flooded island sites.

Filling flooded island areas will entail a variety of permitting, design, and construction feasibility considerations. Dredging and filling waterways requires 401 and 404 permits under the Clean Water Act. These considerations are not addressed in detail in this report, but will be addressed in the subsequent feasibility report. Ideally, many of these issues can be addressed through design and construction innovations that minimize the adverse impacts of filling and dredging of flooded island areas. Some discussion of potential innovations is discussed in the tidal marsh construction section below.

The availability of fill material is one critical feasibility issue that we have considered in this report. The amount of available fill material is a relatively hard constraint on the area of tidal marsh that can be restored in flooded island areas. Fill material could be obtained through dredging flooded islands or by using fill material from upland sites where dredger materials were deposited in the past. Dredging shallow areas (6-9 feet below MLLW) to a depth of approximately 12 feet can prevent colonization of egeria, and the resulting material can be placed in shallow areas to create intertidal marsh. Although, dredged areas may serve as a significant area of fill, we have not specifically identified dredging sites on the theory that they are ubiquitous on both Big Break and Franks Tract. The specific location of dredging sites will be identified in subsequent analysis once we have identified the most promising locations for tidal marsh restoration and packaged them as alternatives with the most promising water quality and recreation elements.

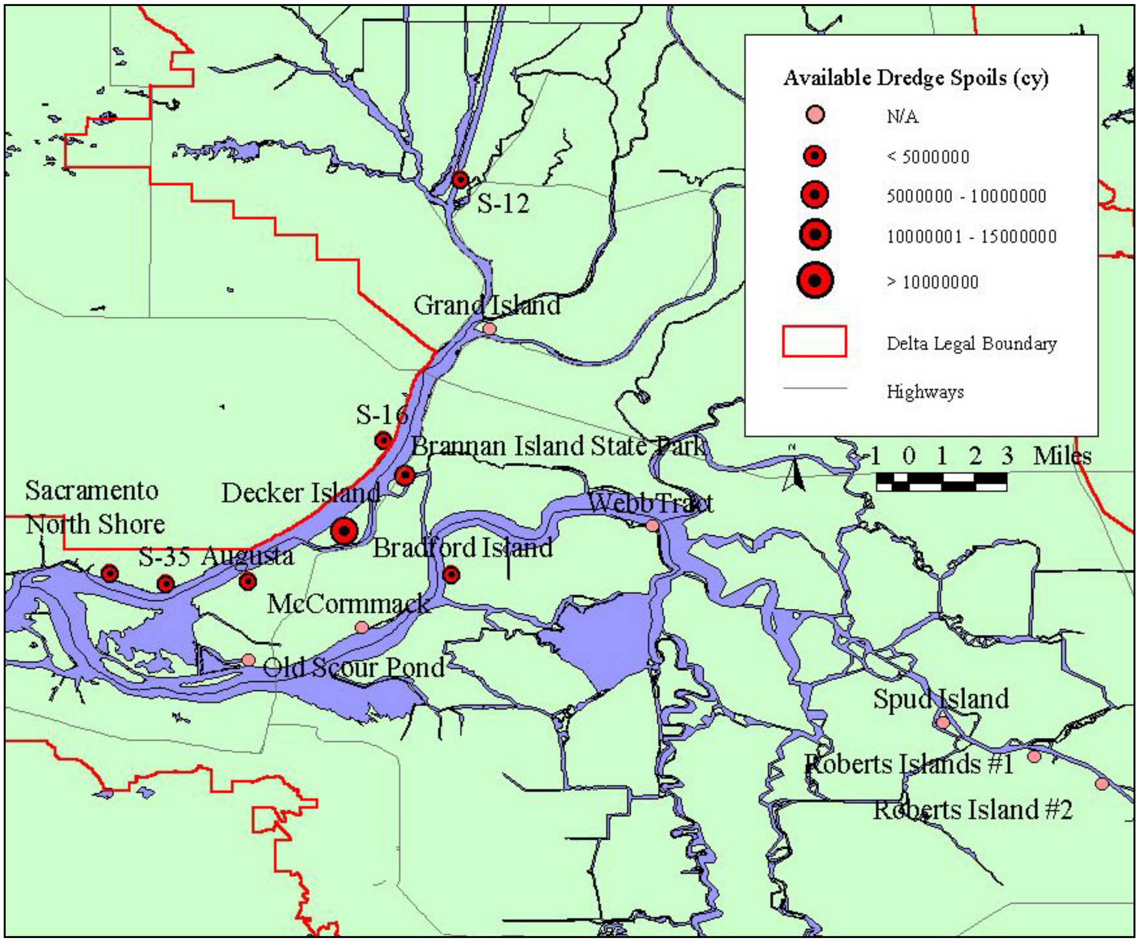
Table 3.1. Quantity and Location of Available Dredge Spoils

Site	**Owner**	**Existing Quantity (cubic yards)**
Augusta	Port of Sacramento	1,000,000[1]
Brannan Island State Park	State of California, Department of Parks and Recreation	9,300,000[2]
Bradford Island	-	1,000,000[1]
Decker Island	DWR, Mega Sands, Port of Sacramento	20,000,000[1]
Grand Island	US Army Corps of Engineers	N/A[1]
Los Ulpinos	US Army Corps of Engineers	2,300,000[2]
McCormmack Tract	-	N/A[1]
Old Scour Pond	DWR	N/A[1]
Roberts Island #1	Port of Stockton	N/A[3]
Roberts Island #2	Port of Stockton	N/A[3]
S-12 (Prospect Island)	Port of Sacramento	1,710,000[4]
S-16 (Rio Vista)	US Army Corps of Engineers	3,000,000[5]
S-35 (Collinsville)	DOW Chemical Company	890,000[4]
Sacramento North Shore (across from Sherman Lake)	US Army Corps of Engineers	3,000,000[2]
Spud Island	Port of Stockton	N/A[3]
Webb Tract	-	N/A[1]
Total		**42,200,000**

N/A- Quantity estimate not available.
[1]C. Schmutte, DWR, personal communication, 2000.
[2]Betchart, 1998.
[3]USACE, 1988.
[4]CRWQCB, 1988.
[5]I. Tavana, USACE, personal communication, 2000.

Table 3.1 provides an estimate of the amount of dredged spoil material available at various upland sites throughout the Delta (figure 3.2). The vast majority of upland dredged spoil material available for tidal marsh restoration is located on Decker Island. There is approximately 20 million cubic yards of fill material available on over 400 acres of Decker Island, currently owned by the Mega Sand Corporation. The Department of Water Resources has considered purchasing this portion of Decker Island to use the dredged spoil for levee maintenance and habitat restoration projects throughout the Delta. Excavation of these materials from Decker would have the added benefit of creating over 400 acres of tidal marsh habitat on Decker Island – a location ideally situated for providing habitat for the numerous native fish species that move up and down the Sacramento River on their annual migrations.

Figure 3.2. Map of Dredge Spoil Sites



Although there are other upland fill material options, the 20 million cubic yards available at Decker Island are almost certainly the most cost effective and realistic source of fill material for flooded island restoration. Other options could add to the total fill available but either marginal in size, reserved for other uses, or less realistic. Many dispersed sites have on the order of 1-3 million cubic yards but they may be intended for use in levee maintenance activities. Brannon Island State Park sits on top of approximately 10 million cubic yards of material, but utilizing this material would require closing or relocating the state park. For this reason, we have assumed that 20–40 million cubic yards is the maximum amount of fill material available. 20 million cubic yards could reasonably be obtained from Decker Island with another 20 million from other upland sites or from dredging in the flood island areas.

3.1.1.3. Tidal Marsh Restoration in Subsided Islands and Mainland Parcels

Restoring subsided Delta Islands to sea level is another option for restoring tidal marsh in the Delta. Some of these opportunities have been previously evaluated in DWR studies (DWR 2002, NHC 2003). This report considers some of the most promising opportunities for restoring subsided islands for the following reasons:

1. Some of the most promising sites are adjacent to flooded islands.
2. Restoring subsided islands may be easier to permit then filling flooded island areas to restore marsh.
3. Restoring subsided islands is a competing demand for the limited amount of upland fill material available to restore tidal marsh in the Delta.
4. Restoring subsided islands to sea level could reduce the potential for levee failure and subsequent island inundation, which would create new flooded islands and associated water quality impacts.

A number of short and long-term strategies for rebuilding subsided islands have been previously analyzed (DWR 2002, NHC 2003). For the purposes of this report, we have only considered short-term strategies for quickly building subsided lands to sea level in order to support tidal marsh. These include use of upland fill material and rice straw bale in combination with construction of new cross levees to separate on-island restoration sites from the remainder of the subsided island.

3.1.2. Marsh Restoration Construction and Feasibility Issues

Several physical and regulatory factors will constrain tidal marsh restoration on flooded and subsided islands.

Availability of Fill Material and Compaction of Peat Soils
Availability of clean fill material is perhaps the single greatest constraint on the amount of tidal marsh restoration feasible on either flooded or subsided islands. This limitation is further exacerbated by the tendency of peat soils to compact when fill is place upon them. A large fraction of the subsided and flooded islands considered as potential marsh restoration sites is underlain by peat soils. These soils can compact by a foot for every vertical foot of fill placed on top of them. For example, filling a 4 foot deep shallow water area with peat substrate could require placing 8 feet of fill per square foot thereby doubling the amount of fill necessary to create marsh relative to mineral soil substrates. Thus, targeting shallow areas with mineral soil substrate is key to maximizing the area of restored tidal marsh.

Rice Straw Bales
Rice grows on four hundred thousand acres a year in the Sacramento Valley. After harvest, two to three tons of straw remain on each acre of land or approximately a million tons of straw a year (Bainbridge et al., 2000). Rice straw used for construction is baled at a density of seven pounds per cubic foot (State of California, 1994). Assuming this

density, one million tons of rice straw creates over 10 million cubic yards of rice straw. Because a surplus of rice straw bale material now exists due to laws restricting disposal by burning, the use of rice straw provides a significant opportunity for synergistic use of a waste material. Currently, farmers either use scarce water to break down rice straw in winter months or they simply stockpile excess rice straw bales.

The greatest advantages of rice straw relative to other fill materials are its relatively low density, low cost, and abundance. Further, rice straw approximates the character of decomposed tules that originally formed the Delta's peat soil more than any other fill material we considered. Unlike dredge spoils and other mineral soils, relatively large volumes of rice straw can be deposited on the Delta's organic soils without causing large amounts of soil compaction. Rice straw costs are less than $1 per cubic yard delivered to the site compared to more $5-$20 per cubic yard for dredge spoils).

Water Quality Impacts of Dissolved Organic Carbon Generated by Tidal Marsh Restoration

Restoring tidal wetlands could potentially increase the level of dissolved organic carbons (DOCs) in Delta waters. Dissolved organic carbons provide nutrients that can benefit the ecosystem by enhancing productivity (Jassby et al. 1993), but when disinfected with chlorine, chloramine, or ozone as part of the drinking water treatment process, they can be harmful to human health (DWR 1994, DWR 2002). Current land uses in the Delta and its watershed currently provide significant inputs of dissolved organic carbons to Delta waters (Amy et al. 1990). Some forms of DOC play an important role in the formation of a variety of chemicals referred to as disinfection byproducts (DBPs), which are suspected carcinogens. These compounds are formed when water is disinfected in drinking water treatment plants. There are various forms of DOC, and some of them are more prone to forming DBPs than others (Fram 1999).

Since over 22 million people currently drink some water diverted from the Delta, it is essential to understand and evaluate the potential impacts of tidal marsh restoration on water quality before proceeding with full-scale implementation. Tidal marsh restoration in the Delta will create DOC, but it is unclear whether they will create more or less harmful DOC than already exists (Brown, draft). The net impact of restoring farmlands or flooded islands to wetlands is unclear. Depending on the type of restored wetland and a variety of factors including soil, location, and hydrodynamics, the restored wetland may create more or less reactive DOC than the agricultural land it replaced. A review of Jassby et al. (1993) indicates that restored tidal wetlands will export organic carbon to adjacent deep-water habitats, but it is unclear how much will be exported or whether it will significantly increase formation of DBPs.

Some fraction of the DOC exported from tidal wetlands may be entrained in drinking water diversion, but it is uncertain how large this source amount and reactivity would be compared to other sources of DOC. The amount and types of DOC created by a particular wetland restoration project and entrained at the drinking water diversion will vary depending on the location, soil, and habitat type. Restored tidal marsh in the western Delta, downstream of the drinking water diversions, will probably be a relatively small source of DOC in drinking water compared to tidal marsh and floodplain sites located further upstream.

Anaerobic decomposition of rice straw under inundated conditions could create negative water quality problems. Again, however, we assume that restoration of sites in the western Delta is less likely to impact water quality in the southern Delta.

3.1.3. Avian Habitat Islands

Creation of relatively small wetland islands could provide significant benefits for avian, herptofauna, and plant species. We have assumed that restoration of dentridic tidal marsh to benefit native fish requires relatively large patch sizes to make a substantial impact, but much smaller wetland islands could have benefits for a variety of other species. The type of ecological benefits would vary according to the type of habitat created. Low lying marsh may create habitat for waterfowl. Uplands could provide nesting sites for waterfowl along with nesting and basking sites for herptofauna. Riparian habitat could provide nesting and roosting habitat for a variety of piscivorous water birds.

This report does not identify specific opportunities for creating small islands, but this should be considered in subsequent alternatives development and analysis. Identifying suitable sites and creating these habitats should be considerably easier then identifying large marsh restoration sites. We have developed one representative island restoration scheme, however, to evaluate the amount of fill necessary to create a large number of acres scattered throughout a flooded Island. The feasibility of creating small sites is far greater due to the relatively small amount of fill material required. However, small sites may be particularly vulnerable to erosion or disturbance by recreational boaters. It will be most efficient to identify sites for creating small islands once the flooded island project team identifies the most promising alternatives for simultaneously achieving broader scale water quality, ecosystem, and recreation objectives.

3.1.4. Carbon Management for Primary Productivity Enhancement

The configuration and hydrodynamics of flooded islands influences the rate of net primary productivity in the form of phytoplankton (Lucas and others 2002) and its transport to other parts of the estuary. This suggests that it may be possible to alter the configuration and hydrodynamics of flooded islands to increase primary productivity and thereby increase the food supply for zooplankton that form a large and important part of the diet of declining native fish species. Changes in the configuration and hydrodynamics of flooded islands could also increase the flow of dissolved organic carbon (DOC), a byproduct of primary productivity, to the drinking water intakes in the southern Delta.

The objective of this ecosystem restoration element is to maximize the export of phytoplankton to western Delta and estuary from the flooded islands and to minimize the transport of DOC to the water diversion intakes in the central and southern Delta. Because the science of the processes that control net phytoplankton production and export is not fully developed (Lucas 2002), prudent pursuit of this objective requires an adaptive management approach whereby various approaches are incrementally implemented in and experimental context. In the section below, we review some of the relevant science on this topic and suggest a couple of alternatives that could be evaluated in subsequent feasibility analyses and adaptive management experiments.

Brown (2003) provides a useful summary of previous studies regarding the role of primary productivity and the processes that control it.

> "Decreased ecosystem productivity has been suggested as a contributing factor in the declines invertebrates and fishes of concern in the estuary (Bennett and Moyle 1996; Kimmerer and Orsi 1996; Orsi and Mecum 1996). This hypothesis is based on observations that concentrations of chlorophyll-a in estuarine water-a measure of standing crop of phytoplankton- have declined and remained depressed since the mid to late 1980's (Jasby and others 2002). The mechanisms proposed for this decline have included export of primary production from the Delta by the federal and state water facilities (Jassby and Powell 1994), and consumption of phytoplankton in Suisun Bay by the introduced Asian clam, *Potamocorbula amurensis* (Alpine and Cloern 1992; Jasby and others 2002). However, analyses of the existing data indicate a considerable seasonal and annual variability in the system even after these and some other likely mechanisms are considered (Jassby and others 2002). Whatever the mechanism, reductions in phytoplankton populations- and easily assimilated form of organic carbon (Sobcxac and others 2002)- result in less food for upper trophic levels (consumers), including the zooplankton that form a large part of the diet of larval and juvenile fish of most species and the adults of some species)."

Lucas and others (2002) conducted a field study of phytoplankton production in two flooded delta islands and found that rates of net phytoplankton production varied greatly within and among sites. The study measured phytoplankton production in Franks Tract and nearby Mildred Island – another flooded island. On the whole, the rate of phytoplankton growth available to pelagic grazers in Franks Tract was negative while rates in Mildred Island were positive. Lucas attributed the different growth rates to differences in 1) hydrodynamic processes, 2) the configuration of the flooded islands and associated tidal mixing, and 3) temporal and spatial variation within the flooded islands. In general, areas with longer residence time and less mixing with deep, less productive, channel water outside the flooded tracts resulted in greater growth.

We hypothesize that it may be possible to increase phytoplankton growth available for consumption by zooplankton in the western Delta and Suisun marsh by temporarily increasing residence in the flooded islands and then preferentially releasing water on ebb tides to transport it toward the western delta. The water quality section of this report describes a variety of alternatives preliminarily suggested by Burau (Burau, 2004). By installing operable tide gates on the western edge of Franks Tract and or False River, it would be possible to control residence time in Franks Tract and then release water and associated phytoplankton in Franks Tract on the ebb tide for transport to the western Delta. The operable gates are necessary to maintain relatively short residence times in Franks tract to control the spread of *Egeria*[1] and to reduce the possibility of nuisance algal blooms.

It may be possible to further increase phytoplankton production by connecting Little Franks tract to Franks tract, rebuilding the north and west levees of Franks tract, and directing tidal flows into and out of Franks Tract via little Franks tract. This scenario requires the removal of the levee that separates Franks Tract from Little Franks Tract and perhaps some dredging of Little Franks Tract to enhance exchange. This levee material could be used as material elsewhere in the project. This scenario has the best chance of growing carbon because Little Franks Tract is narrow and is oriented normal to the prevailing winds, and thus wind mixing will be minimal in this area which could promote phytoplankton growth.

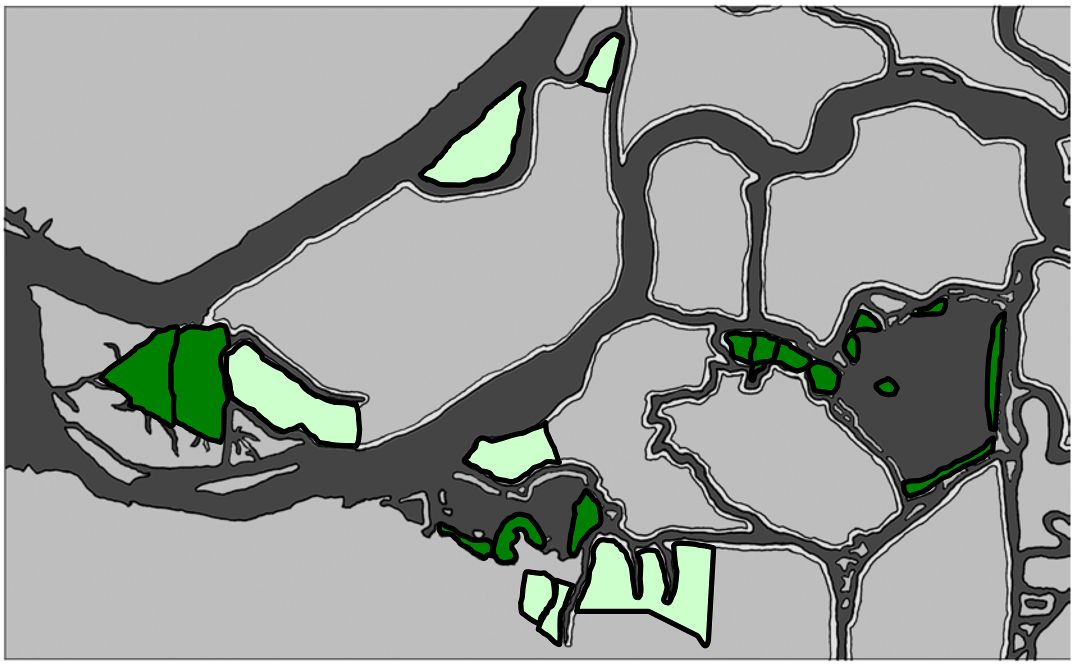
As discussed above, an incremental adaptive management approach would be the best way of improving primary productivity and other water qualtiy parameters without inadvertently creating adverse impacts. One adaptive management approach might be to start by connecting Little Franks Tract to False river with an operable gate. If the intervention peforms as expected, the next step would be to remove the eastern levee on Little Frank tract to connect it with Franks Tract. If successful, the final step would be to repair the western and northern levee of Franks tract.

[1] Egeria is presumably controlled by increasing turbidity and thereby reducing light required for egeria growth.

3.2. Restoration Site Evaluation Approach

3.2.1. Criteria

Figure 3.3. Overall map of tidal marsh restoration sites



We identified and evaluated a range of potential tidal marsh restoration sites in flooded (dark green) and subsided (light green) islands (figure 3.3) based on the following criteria listed in order of importance:

- Depth of flooded area or subsidence
- Substrate type and associated compaction factors
- Size of restoration area and proximity to existing marsh areas
- Potential length of edge habitat
- Erosion risk
- Proximity to high velocity channels
- Potential for access to restored marsh via deep, SAV free water
- Potential for topographic diversity

These criteria are described in greater detail below. Depth, substrate, and size characteristics were most amenable to quantification. Based on a combination of depth and substrate (mineral vs. organic), we were able to approximate the amount of fill necessary per acre of marsh restored – a robust measure of the cost efficiencies associated with different sites.

We attempted to identify several large, but discrete tidal marsh restoration sites with the objective of significantly increasing tidal marsh area in the western Delta. We tempered this pursuit of maximizing tidal marsh restoration, however, with the knowledge that area of restored tidal marsh will ultimate be constrained by the amount of fill available. We therefore only targeted areas less than 6 feet below mean lower low water.

We identified 19 flooded island restoration sites with a combined total of 3,200 acres and a total fill requirement of approximately 50 million cubic yards. This compares to the 20 million cubic yards available from Decker Island, another theoretical 35 million cubic yards available from other upland dredged spoil sites (including Brannan Island), and a yet to be determined quantity from dredging flooded island sites. In reality, the fill constraints dictate that it may only be possible to restore roughly half these sites.

We also identified another 3,400 acres of subsided island and mainland sites that could be restored to tidal marsh with a calculated fill demand of 75 million cubic yards. The bulk of this fill demand, 64 million cubic yards, is associated with the 1,870 of subsided lands on Jersey Tip and Mayberry Point. Given the fill constraints, it would not be realistic to relatively quickly restore these large sites without the use of rice straw bale or some other fill material. It may be possible, however, to gradually build these large subsided sites up to sea level over the next century through bio-accretion with managed tule cultivation.

We have not identified potential channel networks within or between these restored sites but plan on doing this analysis in the next phase of work, based on input from the Flooded Island project team and technical advisory committee. Channel network connectivity between these sites could significantly determine their hydrodynamic input and their benefits for primary productivity and native fish species. This analysis, however, would be more efficient within the context of integrated water quality, restoration, and recreation alternatives.

Depth of flooded area or subsidence
This is a simple measure of the depth of flooded areas below sea level. We estimated average depth of flooded areas based on bathymetric maps and subsided areas based on topographic maps. Due to known fill availability constraints we targeted areas below 6 feet in depth with an average depth of 4 feet.

Substrate type and associated compaction factors
We classified substrate into 3 types: mineral, organic, and mixed. We targeted mineral soil sites, but selected numerous mixed and organic soil sites due lack of mineral soil areas and a general lack of good data regarding soil type on flooded islands. There is not adequate data to accurately classify substrate types on flooded islands, but we made a best approximation based on regional soil patterns from NRCS maps along with historic aerial photographs and topographic maps of flooded island sites prior to the historic levee failures that caused their inundation. We assumed that light colored soil, visible on historic aerial photographs of Franks Tract, represented mineral soils (delhi sands) while dark soils represented organic soils. We were unable to locate historic aerial photographs of Big Break, which flooded in 1929, and Sherman Lake, which flooded in the nineteenth

century. In these cases, we made approximations based on the known depth, topographic features on the 1910 Big Break topographic map, and regional soils patterns. We determined soil types on subsided islands based on NRCS soils data.

Size of restoration area and proximity to existing marsh areas
Size of restoration area and proximity to existing marsh areas is based on the assumption that large patch sizes of marsh are necessary to support dendritic tidal marsh and are otherwise preferable to native fish species compared to small patch sizes. Total patch size was calculated by adding the maximum acreage of the potential size restored site (given depth and substrate constraints) with the acreage of adjacent marsh areas.

Potential length of edge habitat
We also assumed that length of edge habitat was a desirable feature but deemed it less important then patch size. Interestingly enough, most of the options we evaluated did not significantly increase the length of edge habitat because of their contiguous proximity to existing edge habitat. New linear islands, such as restoring the eastern levee of Franks Track, did significantly increase edge habitat.

Erosion risk
Erosion risk was selected as criteria to base against the selection of restoration sites that would be prone to erosion by high velocity currents or wind waves. Erosion risk was estimated based on prevailing wind patterns and known high velocity areas, such as the “nozzle” in western Franks Tract. We assumed that the most erosive wind waves were associated with frontal weather patterns from the southwest as well as northwestern winds.

Proximity to high velocity channels
We assumed that proximity to high velocity channels was a positive attribute. Marshes adjacent to high velocity channels would be more likely to be utilized by juvenile and larval fish species traveling in the channels, and would allow for maximum exchange of water and nutrients to and from the marsh areas.

Potential for access to restored marsh via deep, SAV free water
Deep-water areas (greater than 12 feet deep) are less likely to be colonized by submerged aquatic vegetation (SAV) (Anderson, pers. com 2004). SAV harbor exotic fish including piscivorous fish that prey on native juvenile fish, which marsh areas are designed to benefit. Furthermore, SAV blocks access to the marsh, reducing the possibility that native fish will find and utilize the marsh.

Potential for topographic diversity
Sites with greater potential for topographic area were given preferential bias under the assumption that topographic diversity will result in habitat diversity and associated species diversity. Mainland sites near Big Break were the only sites with greater potential for topographic diversity due to their proximity to upland areas on the edge of the Delta. Potential sites in flooded and subsided islands have less potential for

topographic diversity, although such diversity could be designed into the project by simply adding more fill material.

3.2.2. Matrix Discussion

Table 3.2. Potential Marsh Site Evaluation Matrix

	Avg. Depth (below MLLW)	Substrate		Maximum Size	Potential Patch Size**	New edge	Erosion Risk	Proximity to High Velocity	Marsh Entry SAV-Free deep Water	Topographic Diversity	Max Fill (per million cubic yards)	Percent of Decker Material	Fill per acre (per 1,000 yds.cubed)	Rank
		Type	Compaction Factor											
Decker*	NA	mineral	1	400							-20	100%	-50.0	H
Sherman Lake														
W.Central Sherman Lake	4	organic	2	315	large	small	M	yes	yes	L	5.4	27%	17.1	M
E. Central Sherman Lake	8	organic	2	501	large	medium	H	good	yes	L	14.8	74%	29.6	L
Big Break														
Central Point - Big Break	3	mixed	1.5	173	large	small	M	poor	no	M	1.8	9%	3.6	M
Eastern Big Beak	4	mixed	1.5	200	large	medium	M	poor	no	M	2.5	0%	0	M
Western Big Break	4	mixed	1.5	135	large	large	M	good	yes	L	1.7	9%	12.8	M
Little Franks Tract														
West Little Franks	4	organic	2	103	medium	small	L	good	yes	L	1.8	9%	17.1	M
Central Little Franks	6	organic	2	87	small	small	L	good	yes	L	2	10%	23.3	L
East Little Franks	4	organic	2	91	small	small	L	good	yes	L	1.6	8%	17.1	M
Horseshoe Point	3	mineral	1	87	small	small	L	poor	yes	M	0.7	3%	7	M
Franks Tract														
S.W. Franks	4.5	mineral	1	176	medium	small	L	good	yes	L	1.7	8%	9.3	H
N.W. Franks	6	organic	2	59	medium	small	L	good	yes	L	1.4	7%	23.3	L
North Nozzle	5	mineral	1	17	small	small	M	good	yes	L	0.2	1%	10.1	M
Skaggs Island	4	mineral	1	21	small	medium	H	good	no	L	0.2	1%	8.6	M
S.E. Levee	4	mineral	1	129	medium	small	H	good	no	L	1.1	6%	8.6	H
East Levee	5	mixed	1.5	104	medium	large	H	good	no	L	1.6	8%	15.2	M
N. Levee	4.5	organic	2	40	medium	small	H	good	no	L	0.7	4%	18.7	M
Central Franks Tract	8	organic	1	500	large	large	L	poor	no	L	7.4	37%	14.8	M
13 Linear Islands	8	organic	2.5	110	small	large	H	poor	yes	L	4.1	20%	36.9	NA
Subtotal				3248							51			
Subsided Island Restoration														
Jersey Point	9	organic	2	860	medimum	large	L	good	yes	L	28.0	98%	32.7	
Mayberry Point	10	organic	2	1010	large	large	L	good	yes	L	36.0	179%	35.8	
Dutch Slough	2	mixed	1.5	1132	large	large	L	fair	yes	H	9.2	49%	8.2	
N.E. Tip of Sherman	3	mixed	1.5	175	small	large	L	good	yes	L	1.8	8%	10.5	
Mouth of Marsh Creek	-3	mineral	1	106	large	medium	L	fair	yes	H	-0.25	-1%	-2.3	
Big Break Mainland	-1.5	mineral	1	154	large	medium	L	poor	no	H	0	0%	0.0	
Subtotal				3437							75			

*Above MLLW. Necessary fill source for other sites.

**Potential patch size considers proximity to existing marsh areas or planned restoration sites

Table 3.2 evaluates 18 different marsh restoration options according to the criteria described above and provides a preliminary ranking of the alternatives. Rank is based on the amount of fill required per acre, combined with a qualitative assessment of the other criteria. The amount of fill per acre (Q) is a function of average depth (D) and estimated substrate compaction rates (C) divided by the total number of acres at each site (A):

$$Q=(D)(C)/A$$

The amount of fill per acre and the corresponding rank for each site is highly sensitive to compaction rate estimates. Compaction rate estimates are rough approximations due to a lack of data on substrate types for the flooded island sites and a lack of data on actual compaction rates where soil types are better known. We assumed a compaction rate of 2 for peat soils, 1.5 for mixed soils, and 1 for mineral soils. Areas with a compaction rate of 2 required twice as much fill as similarly deep sites with mineral soils. Subsequent analysis is necessary to better characterize substrate types and estimate likely compaction rates.

Despite the uncertainties associated with substrate and compaction factors, figure 3.1 clearly identifies some of the most and least promising options. Restoration of shallow mineral substrate areas such as "south west Frank Tract" appear promising, while restoration of deep organic sites such as central Franks Tract or western Sherman Lake seem inefficient.

3.2.3. Compatibility of Site Options with Water Quality Elements

3.3. *Description of Alternatives*

3.3.1. Tidal Marsh Restoration Options in Franks and Little Franks Tracts

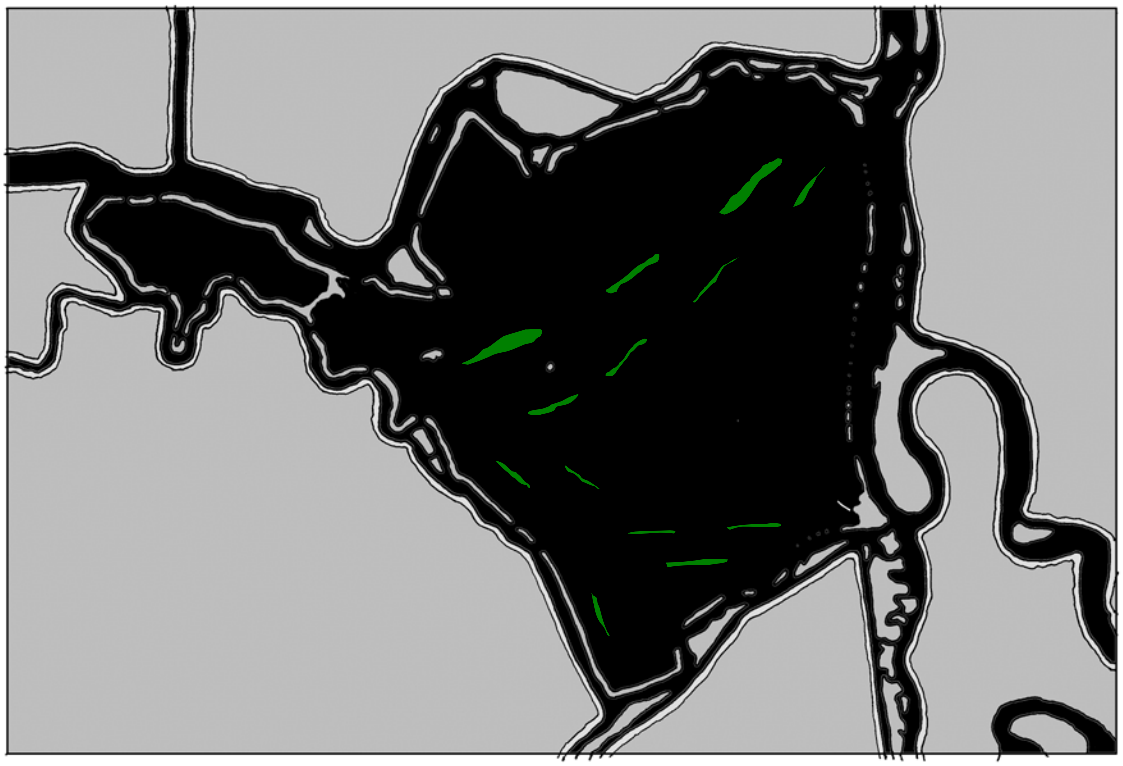
Figure 3.4 depicts eight tidal marsh restoration site options in Franks Tract and four restoration site options in Little Franks Tract. Depending on fill availability, all of them could be implemented independently or in combination with one another. The combined area of all eight sites in Franks Tract is 1,150 acres – approximately 1/3 of the entire tract. The four sites on Little Franks tract total 370 acres and encompass the entire tract.

Figure 3.4. Tidal marsh restoration sites in Franks Tract

Figure 3.5 below is a representative map of a potential island configuration scheme in Franks Tract. Each linear island is approximately 100-150 feet wide. This scheme is a hybrid-attempt to depict and evaluate:

- The potential configuration and fill demand requirements to create numerous island habitats for birds and other non-fish species.
- The potential to configure islands to significantly alter wind wave and other hydrodynamic patterns that may control water quality.
- The potential to reduce wind fetch and associated wave in order to maintain dredged boating channels without frequent maintenance dredging (discussed further in the recreation improvement section).

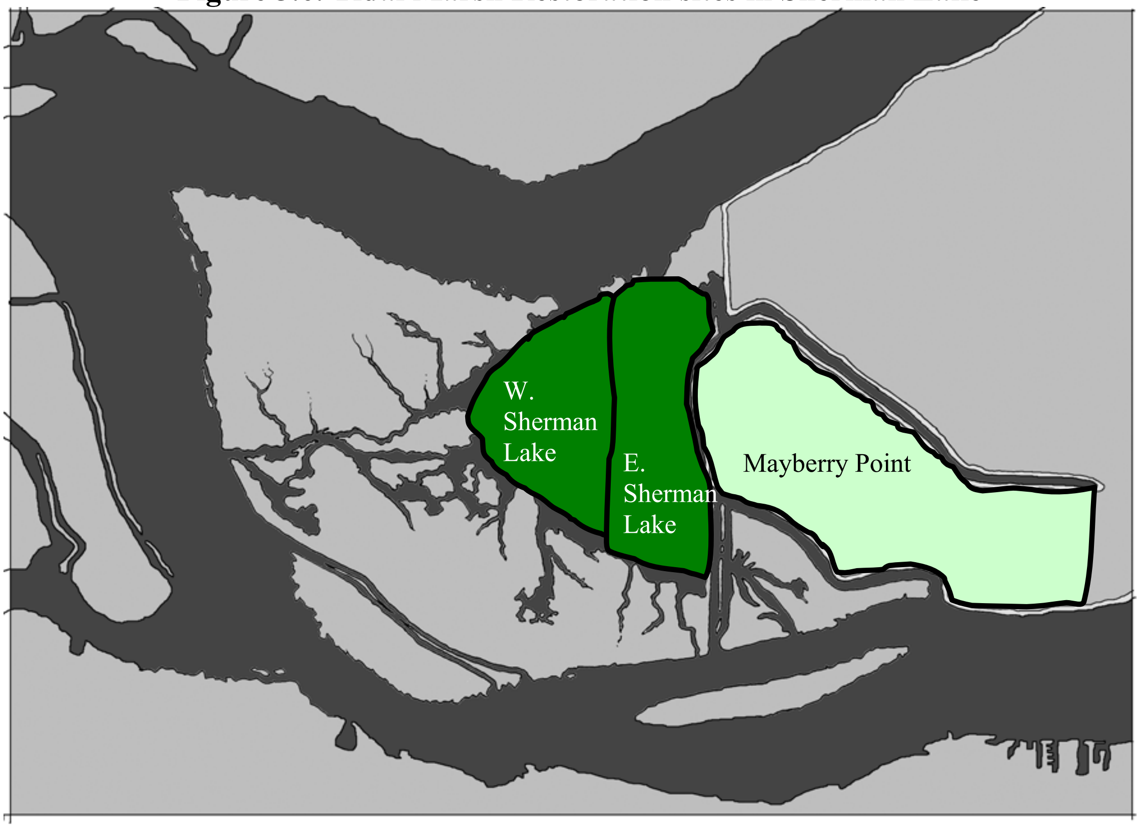
Figure 3.5. Representative map of island configuration in Franks Tract



3.3.2. Tidal Marsh Restoration Options in Sherman Lake and on Sherman Island

Figure 3.6 below depicts tidal marsh restoration site options in Sherman Lake. We considered only two options, totaling approximately 800 acres, for Sherman Lake. The west central site was identified due to shallow water depths. The east central site was identified for comparative purposes despite its average depth of eight feet. In the absence of any data, we assumed that both sites were underlain by organic soil based on the soil types described for nearby Mayberry Point. This is probably accurate for eastern Sherman Lake, but western Sherman Lake may be underlain by mixed soils based on its depth and proximity to extant marsh.

Figure 3.6. Tidal Marsh Restoration sites in Sherman Lake



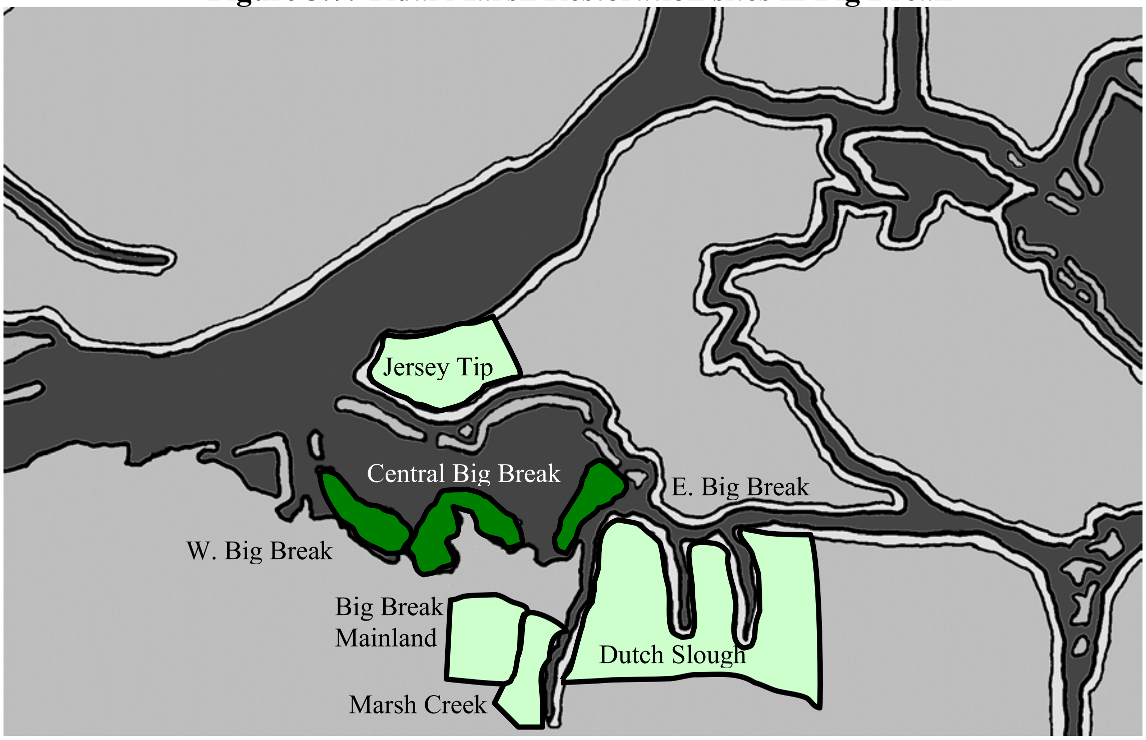
We considered two options for reversing subsidence on Sherman Island, as well as excavation of Decker Island. Restoration of Mayberry Point on the western edge of Sherman Island would create 1,000 acres of tidal marsh but would require 36 million yards of fill material due to its subsided depth and organic soils. Restoring this area to tidal marsh in a relatively short time frame would require utilizing rice straw bale or some other sources of light-weight fill material.

Restoration of 175 acres on the northeast tip of Sherman Island is the second option we evaluated. We identified this option due to its relatively high elevation. This site also has the potential to significantly alter hydrodynamics associated with 3-mile slough. Much of this site, however, is in private ownership and would require the consent of landowners to implement restoration.

3.3.3. Tidal Marsh Restoration Options in Big Break

Figure 3.7 depicts three tidal marsh restoration site options in Big Break, totaling 500 acres. Figure 3.7 also depicts three mainland restoration sites, including Marsh Creek and Dutch Slough. These sites are attractive due to their elevation and mineral soil, but implementation of restoration on these lands would be contingent upon the consent of the Iron House Sanitary District, which currently owns and manages these lands.

Figure 3.7: Tidal Marsh Restoration sites in Big Break



The central point option was identified based on water depth and is designed to both increase the size of the existing marsh and to buffer special resources on the existing marsh that have been identified by the East Bay Regional Park District. The western Big Break option was designed to connect two large islands in western Big Break with the central point wetland. Based on the 1910 USGS topographic map and the distribution of relict Pleistocene dunes, we assumed that both the western and central point options overlie mixed soil types. The western islands and Big Break are relatively high and align with the Pleistocene dune in the region, indicating that there is very likely a band of mineral, or at least mixed soil between the western Islands and the central point wetland.

The western Big Break site option is designed to integrate with the mouth of Marsh Creek that drains a 100 square mile watershed on the northern flank of Mt. Diablo. We assumed that these lands are mixed soils due to mineral soil input from Marsh Creek.

The Marsh Creek site is based on previous plans that NHI developed for restoring a small tidal Marsh on Ironhouse Sanitary District (ISD) lands at the mouth of Marsh Creek. NHI is currently in discussion with (ISD) and the Contra Costa Water District regarding the potential to restore a 50-100 acre marsh and riparian corridor along Marsh Creek both upstream and downstream of the Contra Costa Canal. One of the primary advantages of the Marsh Creek site is that it does not require any fill and could actually generate enough fill to restore 20 to 30 acres in Big Break or 50-100 acres on the adjacent Dutch Slough project. The Marsh Creek site is also one of the few sites with significant topographic diversity with elevations ranging from 2 to 15 feet above mean lower low water.

The 150 acre Big Break mainland site has many of the advantages of the Marsh Creek site, but ISD may not be able to offer it up for restoration purposes. They currently use it as an integral part of the sewage treatment process. Further discussions with ISD are necessary before this option is further analyzed.

The Dutch Slough restoration site is considered here because of its proximity to Big Break and Franks Tract, as well as its potential demand for fill material. Although much of the Dutch Slough site is at elevations suitable for tidal marsh restoration, nearly 40% of the site is actually below mean lower low water. Importing up to 9 million cubic yards of fill from Decker Island is one option for maximizing both tidal marsh and topographic diversity at the Dutch Slough site.

4. Recreation Elements

4.1. Summary of Recreation Elements

Based on preliminary discussions with stakeholders who use the flooded islands and the land management agencies that own them, we have outlined the key recreation functions of the flooded island that should be maintained or enhanced. We have not identified or evaluated site-specific options during this phase, but plan to incorporate key recreation elements into our analysis as we integrate and package the ecosystem and water quality options described above into a range of alternatives. The following is a description of these key elements.

4.1.1. Boating Channels and Access

Maintaining boating access onto the flooded islands is a key concern of many stakeholders. Maintaining boating access may be a legal requirement under the public trust doctrine that governs use and access to navigable waterways.

Boat access is particularly important on Franks Tract since many large boats regularly traverse it in excursions across the Delta. Numerous marinas are located along Piper Slough on the south side of Franks Tract.

Figure 4.1: Stakeholder Recommended Boating Channel Network for Franks

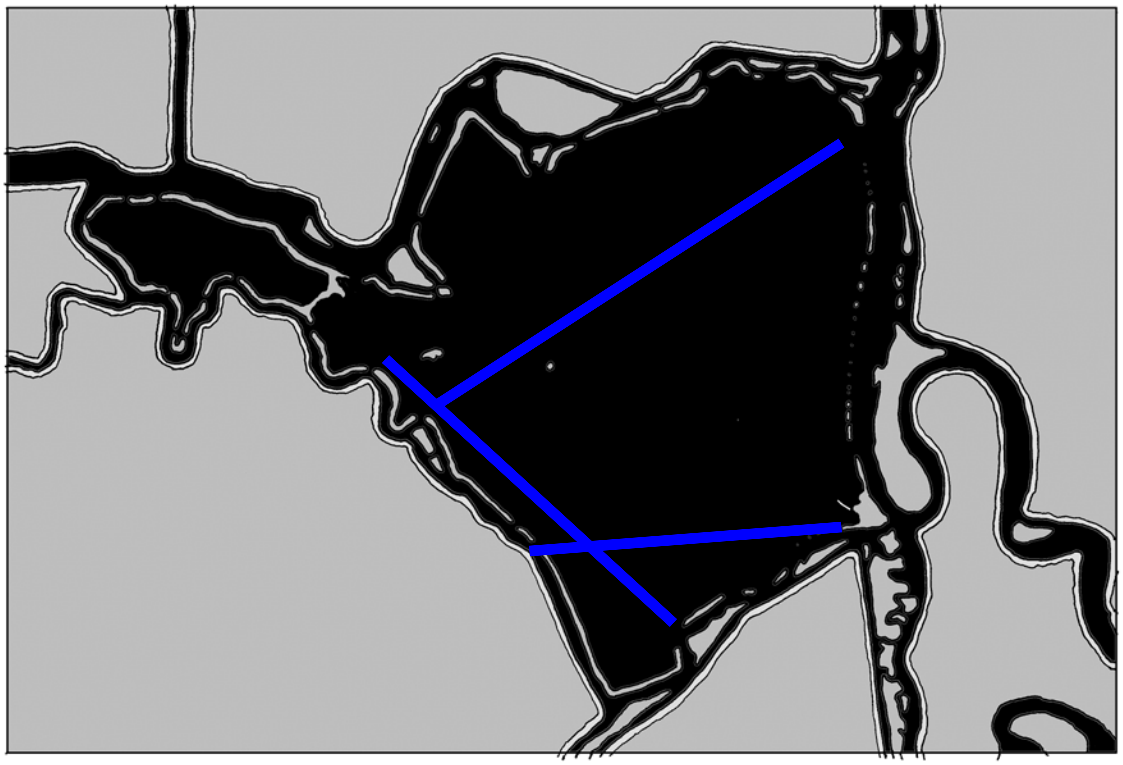
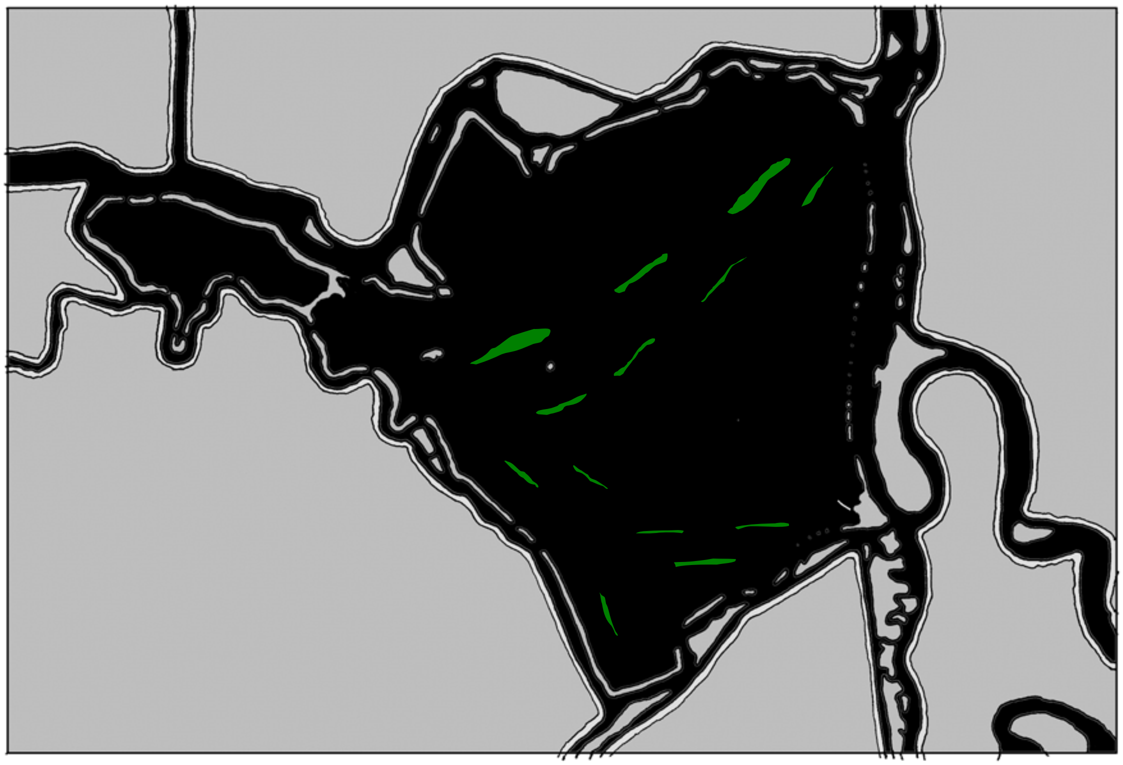


Figure 4.1 depicts a proposed boating channels map for Franks Tract, suggested by Bethel Island Marina owners. The marina owners are concerned that Franks Tract is rapidly filling in or otherwise becoming unnavigable due to dense beds of submerged aquatic vegetation. They suggested dredging each of the waterways to a depth of 12 feet and a width of 100 feet to prevent SAV growth and allow for easy boat passage across Franks Tract. Engineers with Moffat & Nichol expressed concern that dredged channels would rapidly fill in due to re-suspension of bottom sediments from wind waves and high velocity currents through Franks Tract. This would require maintenance dredging and, due to state funding mechanisms as well as permitting issues, it would be very difficult to assure marina owners and recreational boaters that the channels would be maintained over the long-term as part of the Flooded Islands project. Figure 4.2 depicts a conceptual design for configuring linear islands to reduce wave fetch and current velocities and thereby reduce the need for costly maintenance dredging.

Figure 4.2: Boating Channel Network with Habitat Berms to Reduce Wave Fetch, Re-suspension of Bottom Sediment and Subsequent Aggradation of Dredged Boating Channels



Boating access in Big Break and Sherman Lake primarily entails allowing access to the site by relatively small water-craft for fishing and wind surfing in the case of Sherman Lake. Large boats, due to shallow depths, regularly traverse neither Big Break nor Sherman Lake.

4.1.2. Maintain Open Water

Stakeholders identified the importance of open water for aesthetics, water skiing, mooring, and fishing. One component of maintaining open water is reducing the presence of SAV. We need to conduct further discussions and analysis to determine the optimal size and depth of open water for these purposes. It is possible that dredging large open water areas could create large amounts of fill for restoration purposes.

4.1.3. Water Quality/Circulation

Stakeholders expressed concern about maintaining good water quality and circulation in the flooded islands, particularly Franks Tract. They felt that good circulation of water, particularly the high velocity inflow from the "nozzle" on the west side of Franks Tract, was important for maintaining fishing conditions, limiting SAV extent, and preventing noxious odors.

4.1.4. Beaches and Mooring Areas

Recreational features could also be incorporated into project design. Currently, there are only a few existing beach and boat mooring sites. These are very popular with boaters during the summer peak boating period. Setback levees along sloughs and on the inside of the flooded islands may be constructed with new beach areas. These sites might also feature additional amenities, such as landing docks, mooring buoys, floating restrooms, and beach picnic sites.

At Franks Tract, beaches are possible along new levees and within existing “pockets” at several different locations. Sherman Island and Big Break have not been identified as sites for levee repair or modification to improve water quality. Thus, beach construction opportunities would need to be evaluated purely as recreation enhancements. Floating restroom placement would best be determined in coordination with other improvements, such as mooring areas, beaches, and other enhancements, which are most likely to be located at Franks Tract.

Mooring sites should be sited in boater-friendly open areas in concurrence with *Egeria* removal and dredging. Mooring areas could also be created in concurrence with other amenities, such as pocket beaches created adjacent to new levees. Mooring areas would be most advantageous at Franks Tract because of higher use at this site and potential for other amenities, such as beaches, to be located there. These amenities could be developed in association with the mooring areas.

4.1.5. Camping Sites

Another recreation amenity that could be added to an alternative site is a camping facility. Placing floating campsites together would be more efficient for monitoring and maintenance, such as emptying of restrooms and removal of *Egeria*. A more remote experience could be provided if campsites were placed in separate locations rather than a cluster. However, this would require more travel time for monitoring and maintenance activities.

A two-story floating campsite has a vault toilet, picnic table, and barbeque grill. A staircase provides access to the second story. The first story is effectively shaded by the second story floor, whereas sun bathers can use the second story. The upper floor also provides a vantage point that lower elevations don’t provide.

The center floating campsite is designed for windier locations, with one or more sides enclosed. However, substantial anchoring may be required to prevent drifting. Windsurfers may be interested in this type of on-the-water camping. A vault toilet, picnic table, and barbeque grill would also be provided.

Floating campsite locations are more suitable for Big Break and Franks Tract than Sherman Island because of strong winds at that site, although wind is an issue at all three sites. Floating campsites at either Big Break or Frank's Tract would require careful placement and anchoring and possibly wind breaks.

4.1.6. Navigation Locks

Operable tidal gates, which could be constructed to improve water quality, could also provide opportunities for recreation facilities enhancements. Locks for boat passage would be a necessity for tidal gates installed in the well-traveled sloughs in and near the study sites. With the expectation that locks would require boaters to queue up and wait to pass through the lock, the opportunity presents itself to include facilities near the locks for use by boaters. Basic facilities associated with locks could include floating courtesy docks and nearby picnic sites and restrooms. More substantial amenities might include a small store selling bait and fishing supplies, snacks and beverages, and boating provisions; a pump-out station; and/or a gas station.

4.2. Evaluation and Feasibility

A full analysis of the feasibility of recreational amenities, their cost, their consistency with water quality and ecosystem interventions, and appropriate locations is included in the feasibility report.

References:

Amy G.L., Thompson JM, Tan L, Davis MK, and Drasner SW. 1990. Evaluation of THM precursor contributions from agricultural drains. Journal American Water Works Association 80:57-64.

Bainbridge, D., D. Eisenberg, T. Zink, and L. Bayless. 1995. California Air Resources Board Report: Alternative Uses for Rice Straw in California.

Bergamaschi, B.A., M.S. Fram, and R.Fujii. 2000. Observations Regarding Natural Organic Material and Its Effect on Drinking Water in the Sacramento-San Joaquin Delta. Presented at the CALFED Science Conference, October 5.

Brown, L.R. 2003. Potential Effects of Organic Carbon Production on Ecosystems and Drinking Water Quality In: Larry R. Brown, editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1 October 2003), Article 3.

Burau, J.R. 2004. Franks Tract Scenarios – Working Notes. September 15.

Northwest Hydraulic Consultants. 2003. Analysis of sources and availability of fill material for subsidence reversal in Sacramento-San Joaquin Delta, California. Prepared for the Department of Water Resources as part of the Twitchel Isalnd Subsidence Reversal Studies.

California Department of Water Resources (DWR), Hydro-Focus (Hydro-Focus, Inc.), NHI (Natural Heritage Institute), NHC (Northwest HydraulicConsultants), PWA (Philip Williams & Associates, Ltd.), and USGS (U.S. Geological Survey). Demonstration of techniques for reversing the effects of subsidence in the Sacramento-San Joaquin Delta (ERP-98-C01). Draft annual report, 2002.

Fram M. 1999. Specific UV absorbance, aromaticity, and THM formation potential relationships for DOC in waters from the Delta and throughout the USA. In: Smith L, author. Organic Carbon Drinking Water Quality Workshop Proceedings, Draft Proceedings. Sacramento: CALFED Bay-Delta Program. p 30-32.

Jassby AD, Cloern JE, and Powell TM. 1993. Organic carbon sources and sinks in San Francisco Bay: variability induced by river flow. Marine Ecology Progress Series 95:39-54.

Lucas, L.V., Cloern JE, Thompson JK, and Monsen NE. 2002 Functional Variability of Habitats within the Sacramento-San Joaquin Delta: Restoration Implications.

State of California. 1994. California Codes. Health and Safety Code Section 18944.30